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THE

# Progressive Fish-Culturist

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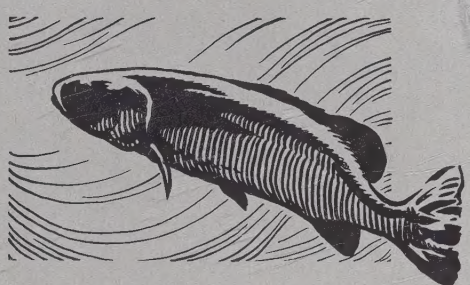

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# THE PROGRESSIVE FISH-CULTURIST

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THE

# Progressive Fish-Culturist

A Quarterly for Fishery Biologists and Fish-Culturists

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# BLOOD SEDIMENTATION RATES OF BROOK TROUT AS AFFECTED BY FURUNCULOSIS

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FOR A LONG TIME it has been known that some acute infectious diseases, especially those of humans, are characterized by a rapid separation of the erythrocytes from the blood plasma before coagulation has occurred. This phenomenon is the basis of a standard test that the diagnostician uses to determine the presence and the severity of infectious diseases such as tuberculosis. Over a short period of time, a small amount of separation of the erythrocytes from the plasma indicates normal blood and little or no infection. Fast separation indicates a severe infection. A return to the normal sedimentation rate indicates recovery from the infection. Abnormally rapid sedimentation rates are usually associated with changes in the electrical charge of the erythrocytes and with changes in the blood chemistry. These changes are considered to be responsible for the sedimentation rates. A review of this subject can be found in Kolmer and Boerner (1938).

As this procedure has been used with success for the indication of human infections, there is a possibility that the same methods can be used for the early detection of infections among hatchery trout. If diseases can be detected in their early stages--before the usual symptoms are noticeable and before an outbreak has attained epidemic proportions--treatments may be more effective and larger numbers of fish saved.

Accordingly, an experiment was undertaken to determine whether sedimentation rates of blood from healthy and from diseased brook trout differ. Two lots of 80 brook trout in the State fish hatchery at Lanesboro, Minnesota, were selected. One lot was believed to be normal and was used as a control group. The other lot showed positive cultures and symptoms of furunculosis. Fish of both lots were approximately 16 months old, and individual weights averaged 1/6 pound.

Sedimentation tests were made with Westergren pipettes graduated to 1.0 millimeter and calibrated to 200 millimeters, placed in a Westergren sedimentation rack. The method and equipment are standard for medical sedimentation tests.

From each trout 1.5 cubic centimeters of blood from the ventricle was withdrawn in a 2-cubic centimeter syringe having a 26-gauge hypodermic needle. The blood was transferred immediately to 5-cubic centimeter vials containing 0.2 milliliter of 6 percent sodium citrate and mixed thoroughly by repeated inversion. The amount of blood extracted from trout of this size allowed filling the sedimentation tube to the 100-millimeter calibration. No fish loss occurred during the experiment. Sedimentation tubes that had been filled exactly to the 100-millimeter mark were placed in the Westergren rack, where readings were taken at 15-minute intervals during 1 hour. Readings of actual sedimentation were multiplied then by 2 to make them comparable to standard tests using the entire 200 millimeters of tube.

Blood sedimentation, expressed in terms of the standard 200-millimeter tube, for the apparently normal group of 80 brook trout was:

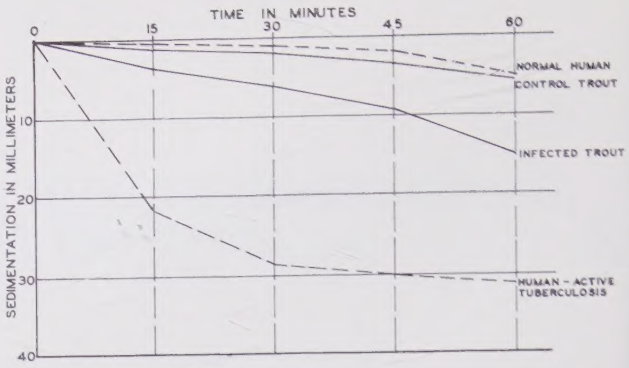
| Reading | Rate | (Average) |
|---|---|---|
| 15-minute | 1 to 2 mm. | 1.3 mm. |
| 30-minute | 1 to 4 mm. | 2.0 mm. |
| 45-minute | 2 to 6 mm. | 3.6 mm. |
| 60-minute | 4 to 8 mm. | 5.5 mm. |

Blood sedimentation, expressed in terms of the standard 200-millimeter tube, for the 80 brook trout which gave positive cultures for Bacterium salmonicida on brain-heart-infusion agar slants was:

| Reading | Rate | (Average) |
|---|---|---|
| 15-minute | 2 to 8 mm. | 3.7 mm. |
| 30-minute | 3 to 12 mm. | 6.2 mm. |
| 45-minute | 6 to 20 mm. | 9.3 mm. |
| 60-minute | 10 to 28 mm. | 14.8 mm. |

It will be observed that at all time intervals (15, 30, 45, and 60 minutes) the diseased fish had a more rapid sedimentation rate than the control fish.

Curves connecting the mean readings for these intervals have been plotted (see figure). For comparison, curves for the normal and abnormal sedimentation rates of human blood (Kolmer and Boerner 1938) are also shown in the figure. It will be seen here that the rate of sedimentation is more rapid in the diseased group of trout than in the control group. Although the differences between the sedimentation rates for control and diseased fish are not so great as the differences that are shown here for human blood, the divergence of the curves for fish blood appears to be real. Use of blood sedimentation rates in early detection and diagnosis of fish diseases appears to have promise.




(Courtesy of the authors.)

Blood sedimentation rates of the apparently normal brook trout and of trout infected with furunculosis, compared with sedimentation rates of normal human blood and human blood taken from a case of active tuberculosis. (Trout readings have been multiplied by two to make them comparable to standard Westergren readings. The human blood sedimentation rates are from Kolmer and Boerner, 1938.)

Before this technique can be used, a normal blood-sedimentation rate curve must be established for each species of fish. Then the characteristic sedimentation rate curve for each disease must be developed. With these curves at hand, it appears that early detection and diagnosis may be facilitated.

## Literature Cited

Kolmer, J. A., and Fred Boerner.
1938. Approved laboratory technic: clinical, pathological ... 2d ed. 893 pp., illus. New York.

RAISING BAIT FISHES, prepared by John Dobie, O. Lloyd Meehean, S. F. Snieszko, and George N. Washburn, is a revision of "Propagation of Minnows and Other Bait Species" and a summary of the results of 5 years of pond investigations by research men in the Midwestern States. The 124-page, profusely illustrated publication is now available as Circular 35 (Fish and Wildlife Service) from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 45 cents.

# RESULTS OF SPECIES HYBRIDIZATION WITHIN THE FAMILY SALMONIDAE

Keen Buss, Pennsylvania Fish Commission, Bellefonte, Pennsylvania
and
James E. Wright, Jr., Pennsylvania State University, University Park, Pennsylvania

THE STUDY ON WHICH THIS REPORT IS BASED was conducted at the Benner Spring Research Station near Bellefonte, Pennsylvania. The original objective of the study was to determine the practicability of utilizing species hybrids of trout for: (a) special-purpose stocking fish, (b) possible use of fertile hybrids in the selective breeding program, and (c) fundamental studies of speciation.

It was thought that if the resulting hybrid progeny should prove to be fertile, backcrossing might be used as a tool to transfer desired qualities from one species to another without losing the identity of the normal species. For example, the possibility exists that the rainbow trout's resistance to furunculosis could be transferred to the brook or brown trout; that the maximum growth and longevity of the lake trout could be incorporated in brook trout; or that the initial growth rate of the brook or rainbow trout could be bred into the brown trout. In view of other findings obtained in plant or animal breeding, this seemed to be a plausible method of obtaining comparatively fast results.

Because of interesting preliminary results, it was decided to publish the information recorded on the hatching and survival potentials of the hybrids. This report is concerned principally with egg viability and sac-fry survival resulting from species hybridization. Further investigations are being conducted to determine fertility, morphology, growth, and characteristics of surviving progeny.

## MATERIALS AND METHODS

With the exception of eyed salmon x brown trout eggs and green eggs of reciprocal matings of brook trout and lake trout obtained from the New York State Conservation Department and from Cornell University, respectively, all eggs were produced and incubated at the Benner Spring Research Station.

Eggs and fry were held separately in compartmented egg trays and fry boxes. The eggs and fry were counted manually, with the exception of lots containing more than 20,000 individuals. The eggs in these larger lots were counted by means of von Bayer's volumetric system, and the fry were counted by a water-displacement process in which sample lots were used to establish an index.

Water temperatures during the incubation period remained at 50° F., plus or minus 1°. The pH was 7.5; the methyl orange alkalinity, 143.0 p.p.m.

In almost all studies, more than one female was used per lot of eggs to eliminate the possibility that the viability of the eggs would be subject to the characteristics of only one parent. When more than one lot was incubated during a spawning season, the results were combined. Results are presented in the table.

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Dr. Wright is Advisory Geneticist to the Pennsylvania Fish Commission.

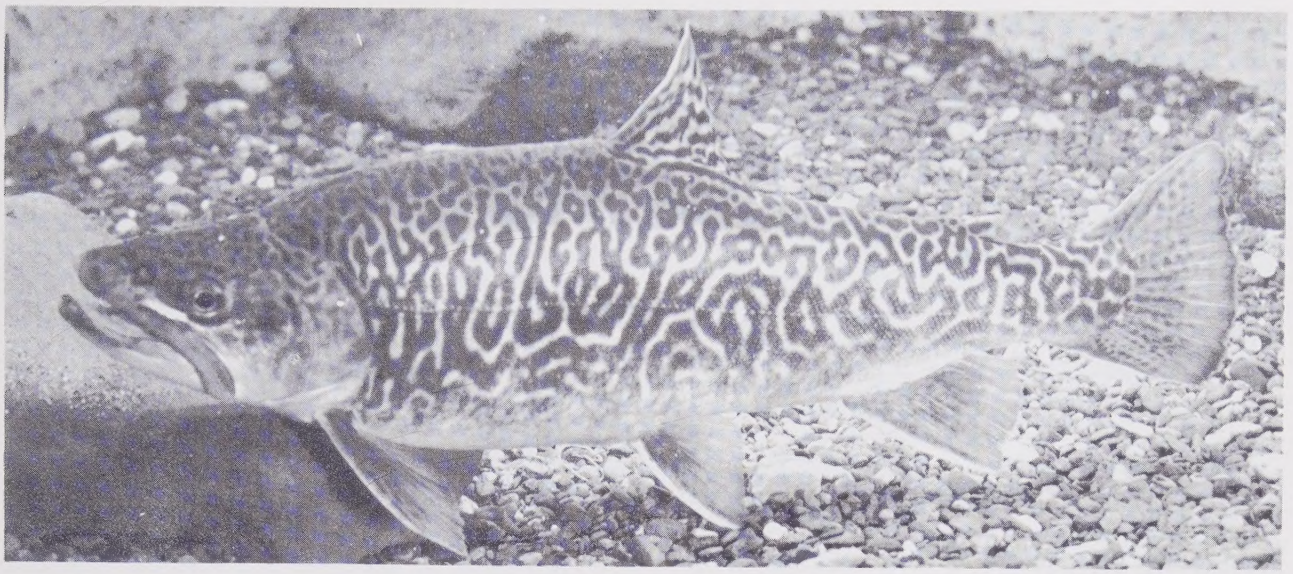
RESULTS OF HYBRIDIZATION EXPERIMENTS

| Trout species | | Fall of year | Number of eggs incubated | Eggs eyed | Number of eggs hatched | Number of surviving fry | Percent of surviving fry[2] |
|---|---|---|---|---|---|---|---|
| Female[1] | Male[1] | | | | | | |
| BT (80) | ST (84) | 1952 | 11,000 | + | 8,030 | 500 | 5.00 |
| BT (80) | ST (84) | 1953 | 100,000 | + | 65,000 | 4,000 | 4.00 |
| ST (84) | BT (80) | 1955 | 4,467 | + | 128 | 22 | .50 |
| RT (60) | ST (84) | 1952 | 8,361 | + | 1,310 | 0 | .00 |
| RT (60) | ST (84) | 1953 | 1,130 | + | 610 | 7 | .60 |
| RT (60) | ST (84) | 1955 | 2,361 | + | 1,336 | 9 | .40 |
| ST (84) | RT (60) | 1952 | 1,762 | + | 0 | 0 | .00 |
| ST (84) | RT (60) | 1954 | 18,014 | + | 0 | 0 | .00 |
| BT (80) | RT (60) | 1952 | 45,473 | + | 0 | 0 | .00 |
| BT (80) | RT (60) | 1953 | 5,662 | + | 0 | 0 | .00 |
| RT (60) | BT (80) | 1952 | 8,456 | + | 14 | 0 | .00 |
| RT (60) | BT (80) | 1953 | 3,380 | + | 1,825 | 40 | 1.20 |
| ST (84) | LT (84) | 1954 | 29,687 | + | 261 | 217 | .70 |
| LT (84) | ST (84) | 1954 | 30,319 | + | 9,782 | 8,500 | 28.00 |
| BT (80) | LT (84) | 1955 | 2,617 | + | 143 | 2 | .08 |
| RT (60) | LT (84) | 1955 | 1,660 | + | 3 | 0 | .00 |
| RT (60) | (LT x ST) (84) | 1955 | 2,942 | + | 1,249 | 60 | 2.00 |
| BT (80) | (LT x ST) (84) | 1954 | 11,145 | + | 11 | 0 | .00 |
| BT (80) | (LT x ST) (84) | 1955 | 3,337 | + | 948 | 107 | 3.20 |
| (LT x ST) (84) | BT (80) | 1955 | 2,814 | + | 9 | 0 | .00 |
| ST (84) | (LT x ST) (84) | 1954 | 47,632 | + | 26,765 | 18,600 | 39.10 |
| ST (84) | (LT x ST) (84) | 1955 | 5,507 | + | 3,371 | 2,844 | 51.60 |
| (LT x ST) (84) | ST (84) | 1955 | 2,233 | + | 209 | 176 | 7.90 |
| ST (84) | (LT x ST)x ST) ( ?) | 1955 | 3,146 | + | 2,575 | 2,514 | 79.90 |
| (LT x ST) (84) | (LT x ST) (84) | 1955 | 51,740 | + | ? | 5,146 | 10.00 |
| ST (84) | (BT x ST) ( ?) | 1954 | 628 | 0[3] | 0 | 0 | .00 |
| ST (84) | (BT x ST) ( ?) | 1955 | 9,650 | +[3] | 0 | 0 | .00 |
| BT (80) | (BT x ST) ( ?) | 1954 | 3,795 | 0 | 0 | 0 | .00 |
| BT (80) | (BT x ST) ( ?) | 1955 | 3,366 | 0 | 0 | 0 | .00 |
| BT (80) | LLS (60) | 1955 | 2,400 | + | 685 | 8 | .30 |

BT -- Brown trout
ST -- brook trout
RT -- rainbow trout
LT -- lake trout
LLS -- landlocked salmon

[1] Chromosome number in parentheses.
[2] Based on total number of eggs.
[3] One egg eyed faintly.

The mortality of the sac fry was calculated from the day on which the last egg hatched. This eliminated the possibility that the dead fry resulted from a ruptured inviable egg rather than from a normal hatching sequence.



(Photographs by K. E. Haupt, Pennsylvania Fish Commission)

Tiger trout (brown trout x brook trout). Two years old.

The success of hatching can be related to the hatchability of normal crosses of brook, brown, and rainbow trout at Benner Spring. The average pickoff of brown trout is 25 percent; of brook trout, 33 percent; and of rainbow trout, 40 percent.

The chromosome numbers are based on investigations by Svärdson (1945) and Wright (1955, and unpublished material[1/]). The following chromosome counts of the salmon family probably have a direct relationship to egg and fry viability: landlocked salmon, Salmo salar sebago, 60; lake trout, Salvelinus namaycush, 84;[1/] brown trout, Salmo trutta, 80; brook trout, Salvelinus fontinalis, 84; rainbow trout, Salmo gairdneri, 60; and splake, 84.[1/]

For the sake of brevity, the progeny of brook x brown trout matings are called tiger trout. This term is suggested by the body markings and the ferocity of feeding habits. Splake is the name given to the progeny of the lake x brook trout. Suggested by biologists of the Ontario Department of Land and Forests, this name is derived from "speckled" (brook) trout and lake trout--hence, splake (Cuerrier 1954).

All counts and percentages of surviving fry are based on the original number of eggs unless otherwise noted.

## BROWN TROUT X BROOK TROUT

### Brown Trout Female x Brook Trout Male

The eyed eggs from this mating were characterized by their viable appearance. Unlike some hybrids, almost all eggs eyed strongly and appeared similar to the eggs resulting from the normal trout matings.

Hatchability of the eggs was about 65 percent, or 10 percent less than in the normal brown trout eggs, and comparable to that of eggs produced from normal brook trout eggs. Newly hatched sac fry, with the exception of cripples, resembled the alevins of brown trout.

As the process of absorption proceeded, there appeared on the sac of most fry a small white spot which eventually spread throughout the sac--and the fry finally died. Smears taken from these white sacs failed to show any pathogenic cause for this condition.

[1/] Wright, J. E. Chromosome numbers in lake trout and splake. Typewritten report, Pennsylvania State University. 1956.

When lots of eggs taken from individual matings were kept separate, there was considerable variation among the lots. Cripples were prevalent in all lots, but some had a much higher percentage of two-headed fry or other malformations.

The mortality of the eggs and especially of the alevins (95 percent, inclusive) precluded the use of these tiger trout as a production hybrid.

### Brook Trout Female x Brown Trout Male

Experiments in 1955 revealed that egg and fry mortality amounted to more than 99 percent. Only 22 fry, from 4,467 eggs incubated, survived.

Alm (1954), from experiments in Sweden, reported a complete loss of this cross over a 5-year period.

In 1954, 35,500 eggs were incubated at Benner Spring and 370 fry were obtained. When these fish were examined in the fall of that year, all the progeny seemed to be pure brook trout in every characteristic and, hence, were discarded in fear that there might have been confusion in transferring the lot from trough to pond. In the spring of 1956, Wright, while conducting chromosome counts on trout eggs, reported seeing a small percentage of cells with haploid (1 n) numbers.[2/] As Olsen (1956) found parthenogenesis in the turkey, this phenomenon could theoretically be possible in a lower animal form such as trout. Therefore, it may have been possible that the 370 trout obtained in 1954 resulted from the parthenogenetic development of the brook trout egg. If this hypothesis is true, then it can be seen that homozygous, true-breeding individuals of a species could be obtained by crossing species, and the resulting hybrid could be distinguished from its parthenogenetic counterpart.

It is notable that, on the basis of these experiments, egg mortality was higher than the reciprocal cross (see table), and the number of survivors was negligible. The choice of the maternal parent species significantly affected egg and fry survival.

[2/] See footnote 1, page 151.

## RAINBOW TROUT X BROOK TROUT

### Rainbow Trout Female x Brook Trout Male

The eggs eyed and fry hatched comparatively well, but fry survival was very low. Alevins seemed to encounter difficulty in absorbing the yolk sac. Within a short period, blue-sac disease appeared.

Blue-sac disease seemed to be prevalent in most hybrids, but seldom affected the controls. Pathologists disagree as to the cause of this disease, but in this study there are indications that blue-sac disease may be caused by some morphogenetic disturbance.

Survival of sac fry was almost negligible (0.05 percent), and, therefore, this hybrid could be considered impractical for any purpose except fundamental research.

### Brook Trout Female x Rainbow Trout Male

The eggs resulting from this mating retained their viability until the eyeing stage but died sometime before the expected hatch. At no time did any eggs hatch.

This is in agreement with Eipper's results at Cornell University.[3/] It is felt that this is due to the distinct difference in incubating time of the eggs of the parent species. No species hybridization has been successful in this study when the rainbow male was used.

## RAINBOW TROUT X BROWN TROUT

### Rainbow Trout Female x Brown Trout Male

In 1952, only a small percentage of eggs hatched and no fry survived.

In 1953, 54 percent of the eggs hatched. Fry mortalities were heavy, however, and only 40 survived to the free-swimming

[3/] Eipper, A. W. Investigation of farm fish ponds and bait ponds in New York State. Typewritten job completion report, Dingell-Johnson Project F-4-R-3. 1955.

Brownbow (rainbow trout x brown trout). Two years old.

stage. Newly hatched alevins appeared immature and soon died.

In 1954, this mating was repeated, but only 2-year-old rainbow trout were available. Egg pickoff was excessive when these early-maturing trout (about 8 percent of the rainbow trout brooders mature at the age of 2 years) were used. Twelve fish survived from the original 10,350 eggs. These figures were not included in the table because of the introduction of another factor--specifically, the age of the female parent.

Brown Trout Female x
Rainbow Trout Male

These eggs eyed, but, as in the crossing of the brook trout female and rainbow trout male, no eggs hatched. The eyes in the eggs were faint and gave the appearance of being "deep-set."

Splake (lake trout x brook trout). Two years old.

Again, it is believed that the difference in egg-incubating time of the parent species was one of the limiting factors. Eipper's study of this cross also noted a complete loss of eggs before hatching.[4/]

## LAKE TROUT X BROOK TROUT

### Lake Trout Female x Brook Trout Male

A survival of 28 percent of the original number of eggs may have been influenced by the fact that green eggs were held until the second day after fertilization before being transported to the research station. However, Eipper's results--33 percent--of survival were comparable to this figure.[4/] Stenton (1952) had a survival of 75 percent.

Blue-sac disease was the principal killer of the alevins. Very few cripples were noted.

### Brook Trout Female x Lake Trout Male

The green eggs were subject to the same transportation factor described for the reciprocal cross.

Significantly, many caudal cripples were found among the progeny. This has been assumed to be directly related to egg size, as lake trout embryos are generally larger than brook trout embryos. Apparently the confinement of a normally larger embryo in the smaller brook trout egg caused the crippling effect. Low survival and crippling of the caudal region were also noted by Stenton (1952) and Eipper.[4/]

## BROWN TROUT X LAKE TROUT

### Brown Trout Female x Lake Trout Male

The fry that resulted from this cross appeared to be very weak in color and vitality. Crippling was prevalent and took its toll of the alevins. Normally formed alevins had enlarged sacs, and many developed blue-sac disease and died. Only two fry survived to swim and feed.

Again, crippling may have been caused by differences in egg size of the parent species.

### Lake Trout Female x Brown Trout Male

The reciprocal cross was not attempted because the lake trout eggs were not available.

## RAINBOW TROUT X LAKE TROUT

### Rainbow Trout Female x Lake Trout Male

Many eggs developed faint eyes but lacked the pink color usually associated with eyed eggs. Three very immature-looking fry hatched, but two died almost immediately. The third fry survived long enough to absorb its yolk sac but did not feed--and soon died.

### Lake Trout Female x Rainbow Trout Male

No lake trout eggs were available for this mating.

## RAINBOW TROUT X SPLAKE TROUT

### Rainbow Trout Female x Splake Trout Male

Eyed eggs appeared normal, but fry were immature and weak in appearance. Approximately 45 percent of the eggs hatched; the loss was probably the result of enlarged yolk sacs and blue-sac disease.

Survival of 60 of the fry was unexpected in view of the other results involving only 2 species of different chromosome count. Further studies are planned to investigate this result.

### Splake Trout Female x Rainbow Trout Male

No mating was attempted.

[4/] See footnote 3, page 152.

## BROWN TROUT X SPLAKE TROUT

### Brown Trout Female x Splake Trout Male

The eyed eggs appeared normal, but the fry had small bodies and large yolk sacs. Blue-sac disease again was prevalent and was responsible for the high mortality.

One hundred and seven fry survived and started feeding.

Perhaps in a three-way cross there are more chances for the brown trout chromosomes to find their compatible counterpart than in the dual-species hybrid. Svärdson (1945) noted that the same species of salmon from three populations migrating in different rivers "differ in respect to one of the large J-shaped chromosome pairs." Therefore, it could be assumed that chromosome compatibility could play a large part in egg viability.

### Splake Trout Female x Brown Trout Male

The nine fry which resulted from this mating had large yolk sacs and did not survive to the free-swimming stage.

As so frequently noted throughout these experiments, the results of reciprocal crosses often differ considerably.

## BROOK TROUT X SPLAKE TROUT

### Brook Trout Female x Splake Trout Male

The first backcrosses in 1954 and again in 1955 showed about 5 percent difference in egg hatchability for the 2 years, but a variation of 12.5 percent was noted when fry mortality was added to the total pickoff.

Hatchability and survival were apparently better in this cross than in the cross of the lake trout female and brook trout male.

Blue-sac disease again took a heavy toll of the fry.

### Splake Trout Female x Brook Trout Male

Approximately 9 percent of the eggs of this cross hatched. Total pickoff of this mating was excessive as compared to the reciprocal cross. Viability of the splake eggs appeared to be lower than that of the eggs of the pure strain of trout; but, as in other reciprocal crosses, a great variation existed.

## BROOK TROUT X (SPLAKE TROUT X BROOK TROUT)

### Brook Trout Female x (Splake Trout x Brook Trout) Male

The hatchability of the eggs and the survival of the sac fry of this second backcross to the brook trout as the recurrent parent exceeded the average results obtained from the pure brook trout matings. Three females were spawned in order to establish an average pickoff.

It is interesting to note that the viability of this mating exceeded that of the first backcross (splake x brook), which in turn exceeded that of the lake trout and brook trout cross. It is possible that this survival is due to chromosome compatibility or hybrid vigor. More research is necessary to determine the statistical validity of figures upon which these assumptions are based.

## SPLAKE TROUT X SPLAKE TROUT

### Splake Trout Female x Splake Trout Male

The fecundity of the splake trout seemed to be lower than either the brook trout and/or lake trout. This condition was noted in part by Stenton (1952). Blue-sac disease again made its appearance and caused a heavy mortality among the sac fry.

Time did not permit the counting of dead eggs and fry of this mating, as the incubation period was concurrent with the time of heaviest spawning activity at the research station.

## BROWN TROUT X LANDLOCKED SALMON

### Brown Trout Female x Landlocked Salmon Male

Twenty-four hundred eyed eggs were received. Many of the eggs developed blood vessels and faint eyes, in contrast to the remainder, which appeared as normally eyed eggs. Many of the fry were very weak and looked immature.

An exceptionally high percentage of cripples was noted. It is possible that the egg sizes of the parent species were too dissimilar. Crippling seemed to be centered in the notochord, in the vicinity of the dorsal fin.

### Landlocked Salmon Female x Brown Trout Male

It was impossible to obtain the fertilized eggs for this mating. On the basis of other experiments, it would appear that this cross should be more successful, as the larger salmon egg could be expected to accommodate the larger embryo.

## BROOK TROUT X TIGER TROUT (BROWN TROUT X BROOK TROUT)

### Brook Trout Female x Tiger Trout Male

Although the testes in some tiger trout seemed to develop normally, sperm could not be taken by the usual methods. The male trout was killed, and the gonads were cut into sections. These sections were then stripped on the eggs. It was doubtful that any milt was obtained by this method. A second method was then attempted. The testes were placed in a commercial blending machine and blended until they were homogeneous. This material was added to the eggs. No fertility resulted from this method of fertilization.

One egg did develop eyes which were barely discernible. This eyed egg came from the lot which had been fertilized by stripping sections of testes. The egg died before hatching.

The reciprocal cross was not attempted because female tiger trout develop only rudimentary eggs or none.

## BROWN TROUT X TIGER TROUT (BROWN TROUT X BROOK TROUT)

### Brown Trout Female x Tiger Trout Male

The procedures used in the brook trout and tiger trout cross were also used here. No viability was obtained.

## RAINBOW TROUT X LANDLOCKED SALMON

### Rainbow Trout Females x Landlocked Salmon Males

Parent fish for this hybridization experiment were unavailable.

H. C. Russ, at the New York Conservation Department's Caledonia Hatchery, has reported (private communication) that in a similar cross about 65 percent of the eggs eyed. Most of the eyed eggs died, and the 20 immature-appearing fry that did hatch died in 2 or 3 days.

Although the chromosome counts of these species are identical (60), a high loss would be expected because the incubation periods of the eggs of the parent species are so dissimilar. These findings correspond to those found in other experiments where rainbow trout females were used. In addition, Bungenberg deJong has indicated (1955) a marked difference in the chromosome structure of these species, and it is possible that chromosomal incompatibility could in some way account for this result.

### Landlocked Salmon Females x Rainbow Trout Males

Again parent species were not available for the cross.

Martin Pfeiffer, aquatic biologist in the New York Conservation Department's Adirondack Fisheries District, has reported (private communication) that at the Warrensburg Hatchery these eggs failed to

eye and, of course, to hatch. The fact that no fry hatched is in direct accord with other experiments when the rainbow trout was the paternal parent.

## SUMMARY

1. Egg viability and fry survival resulting from species hybridization within the salmon family have been studied. The brook trout, brown trout, rainbow trout, lake trout, and landlocked salmon have been used as the parental species.

2. In attempts to hybridize trout species, the length of the incubation period of the eggs of the parent species is an important factor in the hatchability of the eggs. Whenever the male rainbow trout was used to fertilize the eggs of another species, none of the eggs hatched. On the other hand, when the rainbow trout female was employed, some hatchability resulted although the sac fry were very immature in appearance. The incubation period of rainbow trout eggs is approximately 10 days shorter, at 50° F., than the other species. A plausible explanation is that a nuclear-cytoplasm disturbance is operative. This suggests that the incubation periods of the parent species should be nearly compatible for successful hybridization, and that eggs should be taken from the species having the shorter incubation period.

3. In this and in other studies, the size of the egg has been noted to play an important part in the condition and survival of sac fry. For example, the mating of a brook trout female and a lake trout male results in progeny crippled in the caudal region. Reciprocal matings do not generally show this condition.

4. The best egg viability results from crosses of species having the most similar chromosomes, such as matings of brook trout and lake trout. Survival of the sac fry also seems to be directly related to chromosome similarities.

5. If the data derived from these experiments can be regarded as typical, the increase in egg viability as related to the first backcross of the splake to the brook trout and the spawning of their progeny in a recurrent backcross to brook trout may be evidence that chromosome compatibility is an important factor in species hybridization.

6. The high incidence of blue-sac in the sac fry obtained from species hybridization may indicate that this disease does not result from pathogenic causes, but rather from morphogenetic disturbances.

7. Care should be taken in reporting survival and morphological aspects of progeny resulting from species hybridization, as it is possible that a very small percentage of survivors may have resulted from parthenogenesis. If parthenogenesis does occur in trout eggs, this would be a method of developing a homozygous individual. These homozygous fish could be detected easily when hybrid progeny, such as the tiger trout resulting from the mating of brown trout and brook trout, are easily recognizable.

## ACKNOWLEDGMENT

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It would have been impossible to collect all of the data for this paper without the invaluable aid of the foreman, Harold Stitzer, and the other employees of the Benner Spring Research Station.

The eggs from the crossing of brown trout and landlocked salmon were obtained through the courtesy of the New York Conservation Department. Lake trout eggs were obtained through the cooperation of Dr. Dwight Webster, Cornell University.

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## EXCERPT: OBSERVATIONS ON THE FISH POPULATION OF A LAKE CONTAMINATED BY RADIOACTIVE WASTES

"A three-year study of the fish population of White Oak Lake, Roane County, Tennessee, was made in 1950-1953. That lake received the radioactive waste effluent, the chemical waste effluent, and the primary-treated sewage effluent from the Oak Ridge National Laboratory.

"Six semi-annual estimates of the size and composition of the fish population were made by the mark-and-recapture method. Immediately following the last semi-annual netting study, the lake was partially drained and treated with emulsifiable rotenone. Approximately 60 per cent of the fish that had been marked during the last semi-annual netting study were recovered following the treatment with rotenone. The estimated total weight of the fish population was approximately 985 pounds per acre.

* * *

"Radioassay of samples of the various tissues of the black crappie and the bluegill indicated that radiomaterials were selectively concentrated in all tissues of the body. The hard tissues selectively concentrated radiostrontium in amounts 20,000 to 30,000 times that of the water in which they lived. Some radiophosphorus was also concentrated in the hard tissues. The soft tissues selectively concentrated cesium and the rare earths. The total body burden carried by a 7-inch black crappie during the summer of 1952 was more than a microcurie, whereas that for a 6-inch bluegill was only slightly less.

* * *

"The total radiation dose received by the fish in White Oak Lake was estimated to be at least 57 rep /roentgen equivalent physical/ per year from external irradiation and was probably several times that amount from internal irradiation. As a result of this irradiation, it is believed that the fish population of White Oak Lake may have suffered deleterious effects, as manifested by the shortened life span, the slowed growth rate, and possibly the decreased fertility of the breeding stock of the redhorse."

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From the summary of "Observations on the Fish Population of a Lake Contaminated by Radioactive Wastes" by Louis A. Krumholz. Bulletin of the American Museum of Natural History, volume 110, article 4. New York, 1956.

# THE NUTRITION OF TROUT
## II. PROTEIN AND CARBOHYDRATE

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PROTEINS AND CARBOHYDRATES play a major part in determining the success or failure of any trout diet.

### PROTEIN AND TROUT

Protein in the diet of higher animals and the functions of protein in their bodies have been thoroughly investigated. Though few such studies have been made on trout, it may be assumed that the functions of protein in the body of a trout are similar to those in the bodies of higher animals.

#### Functions of Protein in the Animal Body

Protein is the main component of the organs of the animal body, forms the soft tissues, and appears in all the fluids of the body. Protein is used by the body for the formation of enzymes, hormones, and reproductive products. The diet of the animal must contain an abundant supply of protein. It is needed by the animal at all stages of life.

The simplest proteins yield only amino acids (combinations of carbon, hydrogen, oxygen, and nitrogen) or their derivatives on hydrolysis. Linkages of amino acids form complicated particles (molecules) that are the food and body proteins. There are at least 23 amino acids, and a protein may consist of a multitude of combinations of the various acids. Ten of the 23 known amino acids must be supplied in the food for growth and survival of the animal; the others may be made in the animal body.

The percentage of food protein that can be utilized to satisfy the protein needs of the body depends on the protein quality of the food. Protein quality measures the relation of the amino-acid content of the food to the amino-acid content of the body. All protein that is absorbed in excess of the body need, or that cannot be used by the body for protein functions because of poor protein quality, is either burned for energy or stored as fat. Both of these uses are wasteful, because protein is the most expensive of dietary ingredients, cheaper sources of energy are available, and the 16 percent of nitrogen in protein cannot be utilized for energy or for fat formation.

Protein quality is determined in the laboratory by one of two methods:

1. Analyses are made of the amino-acid content of the food and of the body of the animal under study. After comparison, the food protein most closely approximating the amino-acid content of the body protein is considered the highest in protein quality.
2. To a base diet containing all other dietary essentials, various food sources of protein are added. That food protein producing the best growth rate is considered to be of the highest protein quality. These studies are frequently accompanied by analyses of the animal body to determine the amount

of food protein utilized for protein purposes in the body and the amount utilized for fat formation.

Until one of these studies is completed, nothing is known of the protein quality of a food for an animal. As amino-acid analyses are difficult and time-consuming, the second method is more commonly used. Obviously, the application of the second method to any given animal depends on a knowledge of the dietary essentials for growth and survival; without this knowledge, these studies cannot be undertaken.

Another measure of dietary protein efficiency is the ratio of the amount of protein fed to that retained by the animal body. This is called the biological value. The animal is fed for relatively short periods (1 to 4 weeks), during which time accurate records of the food consumed are maintained and separate samples of the urine and feces are collected. From analyses of the food, urine, and feces, the amount of protein absorbed, excreted, and secreted can be determined, and the amount of protein retained by the body can be established. From these data, the biological value of a protein source is calculated.

Until the protein quality or the biological value of a protein source is known, little may be said about the efficiency of a food protein in the animal body. Some animals (chickens, pigs, cattle, etc.) have received intensive study; whereas others, because of difficulty in establishing accurate methods, have received little attention. Trout, unfortunately, are in the latter category.

Protein is digested into the basic amino acids before being absorbed into the animal body. After absorption, the amino acids are either re-formed into protein particles, burned for energy, or deposited as fat. Digestibility of a protein determines the degree of protein utilization. Because of a variance in digestibility of different protein sources for different animal species, a given food source may be excellent for one animal and poor for another. The protein in hay, for example, is used by cattle but is unavailable to dogs.

Protein is vulnerable to bacterial action. Putrefactive products of protein are toxic to the animal body and may cause sickness or death. Protein foods must be handled with care to prevent spoilage. Meats should be frozen, and dry concentrates should be stored in a cool, dry area.

## Protein in the Diet of Trout

Difficulties with experimental procedures and insufficient knowledge of nutritional requirements have limited studies on the protein requirement of trout and the protein quality of trout diets.

Through growth studies (not protein-quality studies) consisting of feeding various dietary mixtures, a level of 28 percent dietary protein has been established as desirable. Trout diets contain as much as 35 percent in the newer types of pelleted foods. A level of 28 percent is high in comparison to the requirements of other animals. Most animals can be reared and maintained on diets containing 14 to 20 percent protein, the exact amount depending on the stage of their life cycle or the purpose for which they are reared. Natural trout foods contain an average of 11 percent protein, and studies have indicated low conversions of natural food into fish flesh and a high deposition of protein in the bodies of wild trout. With increasing knowledge of trout nutrition and improved experimental techniques, it is reasonable to expect that in a few years there will be a better understanding of protein in trout nutrition.

Knowledge of the amino-acid requirements of higher animals has been valuable in establishing the most efficient sources of food protein. Experimental difficulties have precluded such studies with trout. At the Fish and Wildlife Service's Salmon Nutrition Laboratory at Cook, Washington, workers have developed a diet suitable for a study of the amino-acid requirement of salmon. These workers have determined the qualitative requirement of salmon for amino acids. This work is in the process of publication and, when completed, will be of great value in future studies. It is

reasonable to expect that trout will require approximately the same amino acids.

Although protein qualities of foods for trout are unknown, feeding experiments have demonstrated that some foods produce better growth than others. In general, animal concentrates (such as fish meals and dried skim milk) prepared with low heat and under vacuum are superior to those prepared with high heat and under air. Animal concentrates are superior to plant concentrates, but plant concentrates may be used with animal concentrates to reduce diet costs. Dried distiller's solubles are satisfactory and may be substituted for dried skim milk. Fresh meats are excellent growth promoters, particularly when fed with dry concentrates. Fresh meat must be fed to trout to provide unknown dietary essentials and prevent anemia. It is not clear whether meat products promote growth because of protein quality or because of unknown dietary essentials contained. Probably it will soon be possible to eliminate meat from the diet of fingerling trout. As no true protein-quality studies have been reported for trout, it is incorrect to say that one product has a higher protein quality than another.

Several workers have reported studies on the biological value of protein sources in trout diets. To date, these studies have been directed toward method development and no detailed work has been completed. These studies have shown differences in the biological value of protein sources for trout. Beef liver has the highest biological value, and pork and beef spleen have the lowest. Dry concentrates fed with spleens produce biological values either intermediate to those of spleen and liver or equal to that of liver. There is evidence that the biological values of the tested products increase with trout size. It is incorrect to speak of the biological value of a product for trout diets unless the product has been tested experimentally.

Other factors affect the dietary efficiency of protein fed to trout. Poor digestion will reduce the utilization of protein. Fresh meat products are highly digestible, whereas the extent of digestion of dry concentrates depends on the natural characteristics and the method of manufacture. Products processed with high heat (such as tankage, blood meal, and certain meat-scrap meals) are digested less completely than products prepared with low heat. It is generally accepted that plant concentrates are more poorly digested than animal concentrates processed with low heat.

Diet preparation also affects the efficiency of protein fed to trout. Use of an unbound diet results in a loss of protein to the water from leaching, and even bound diets lose the more soluble fractions. Use of pelleted trout foods apparently prevents the loss from leaching: the outstanding conversions of pelleted trout foods into fish flesh support this point.

Slaughter experiments have revealed differences in the protein and fat contents of the bodies of trout fed various diet mixtures. As in many of these studies there is no difference in the dietary levels of fats or carbohydrates, increased trout body fat must be the result of converting protein to fat within the body. This is evidence of the efficiency of some protein sources used in trout diets--and evidence, although not a measure, of a difference in protein quality in trout diets.

To preserve the quality of trout diets, the products must be carefully handled before feeding. Meats should be stored frozen before being ground, and meat-concentrate mixtures should be prepared at frequent intervals and refrigerated between feedings. Putrefactive products can be toxic to trout, and spoiled food should not be fed.

Studies of growth, studies of conversion of food into fish flesh, and analyses of the trout body indicate that the best sources of protein among dry concentrates are vacuum-dried whitefish meal, vacuum-dried menhadden meal, dried skim milk (roller- or spray-processed), dried distiller's solubles, cottonseed meal, and poultry fish meals. Beef liver contains many of the needed vitamins and has a high biological value. Spleens have a lower level of vitamins and a lower biological value but react with salt to bind diet ingredients and improve the efficiency of the

diet. Fresh fish in trout diets promotes growth, but care must be used to prevent a thiamine deficiency. Products such as tripe, lungs, kidneys, and muscle tissue are inferior as growth promoters. Many fish-culturists use lungs to prepare a floating diet, but lungs are less efficient than either spleens or livers.

### Summary

The welfare of the animal body is dependent on the availability of protein. Ten of 23 known amino acids must enter the body as food. The protein quality and the dietary efficiency of protein sources determine the value of the diet. A level of 28 percent dietary protein has been established as desirable for trout. Fresh meats promote growth and provide certain dietary essentials. Preliminary biological-value studies have shown that beef liver is superior to pork and beef spleen. Vacuum-dried fish meals, dried skim milk, cottonseed meal, and dried distiller's solubles are considered good sources of supplementary protein. Animal concentrates are superior to plant concentrates, but both forms are used to reduce diet costs. Indigestibility, poor diet composition, improper diet preparation, improper manufacture or putrefaction of diet ingredients may cause loss of protein.

## CARBOHYDRATE AND TROUT

In contrast to the many functions of protein in the animal body, the role of carbohydrate is limited. Carbohydrates are widespread in nature and form the largest chemical portion of plant products. Because of their chemical composition and their relatively simple role in animal physiology, carbohydrates have been intensively studied not only in higher animals but also in trout.

### Functions of Carbohydrate in the Animal Body

Carbohydrates contain carbon, hydrogen, and oxygen. The simplest forms of carbohydrate are the simple sugars, and in this form they are absorbed into the body. The simple sugars may be chemically combined to form compound sugars or complex carbohydrates. Compound and complex forms of carbohydrate must be digested into simple sugars before they can be absorbed, however, and their availability to the animal body is dependent on the animal's ability to digest them. The compound sugars are readily digested by most animals, but the digestibility of complex carbohydrates varies with the species of animal. Plant feeders (herbivores) easily digest raw complex carbohydrates, but the meat feeders (carnivores) and the combination feeders (omnivores) digest raw complex carbohydrates with varying degrees of effectiveness. A complex carbohydrate (for example, starch) is more easily digested if it has been cooked, as cooking ruptures the hard membrane surrounding the starch grains and allows the digestive juices free access to the starch.

As compared to protein, there is little carbohydrate (usually less than 1.0 percent) in the animal body. The carbohydrates in the animal body are in the forms of glucose (simple sugar) and glycogen (animal starch). Glucose is found in the fluids and cells of the body; glycogen, in the liver and muscle tissues. After being absorbed, carbohydrates are either burned for energy, stored temporarily as glycogen, or formed into fat. The production of energy is the principal use for carbohydrate. Since the energy requirement of an animal may be satisfied by either fat or protein, as well as by carbohydrate, the amount of carbohydrate that is actually needed for life is low. If there is insufficient energy food available in the diet, however, the body will burn protein for energy at the expense of growth and tissue repair. The use of carbohydrate for energy to save protein for other purposes is known as the sparing action of carbohydrate. Excessive carbohydrate in the diet can cause overweight, reduced capacity in the stomach for more essential foods, abnormal deposition of glycogen, and aggravation of diabetes and other pathological conditions.

Diabetes is a condition occurring in the animal body that cannot utilize carbohydrates after they are absorbed. The pancreas of the animal produces a hormone (insulin) which regulates the burning of glucose. If insulin is not produced in sufficient quantities, diabetes results. Injections of insulin will alleviate the condition.

## Carbohydrate in the Diet of Trout

Carbohydrates are a cheap source of food, and there is a temptation to feed them at high levels. Studies have shown, however, that trout are incapable of handling high dietary levels of these foods. In the terms of human beings, trout are considered normally diabetic. The high blood-sugar level in trout after being fed carbohydrates is similar to the blood-sugar levels of human diabetics after a meal. The fact that an injection of insulin will lower the blood sugar in trout to normal indicates that trout are poor producers of insulin. This is further shown by the poorly developed pancreas of trout and the relatively few insulin-producing cells in the organ. Experimental work has shown that trout have a limited capacity for eliminating excess blood sugar in the urine, the normal path of elimination in higher animals. If high levels of carbohydrates are fed to trout over extended periods, glycogen will be deposited in the liver, causing the organ to swell and, eventually, the death of the trout. The amount of carbohydrate that may be added to trout diets is limited by the physiology of the fish.

As the effect of dietary carbohydrate in the animal body is dependent on the digestibility of the food eaten, the harmful effect of carbohydrate in the trout diet varies with the ability of the fish to digest the form of carbohydrate that is fed. Digestion and absorption studies made on trout have shown differences in the digestibility of the various forms of carbohydrate. Following are listed percentages of absorption of carbohydrates that have been fed to trout under experimental conditions:

| Form of carbohydrate | Percent absorbed (36 hours) |
|---|---|
| Glucose, simple sugar | 99.0 |
| Malt sugar (maltose), compound sugar | 93.0 |
| Cane sugar (sucrose), compound sugar | 73.0 |
| Milk sugar (lactose), compound sugar | 60.0 |
| Cooked corn starch, complex carbohydrate | 47.0 |
| Raw corn starch, complex carbohydrate | 38.0 |

The simple sugar, which requires no digestion before absorption, is taken almost completely into the trout body. The compound sugars, which must be digested before absorption, are less efficiently absorbed; and the different types of compound sugars fed show differences in percentage of absorption. Complex carbohydrates, the most difficult to digest, are the least absorbed, although--as in the higher animals--cooking causes increased absorption.

From these studies and from studies in which trout were fed various levels of different carbohydrates over an extended period, it has been established that no more than 9 to 12 percent of the trout diet should be in the form of digestible carbohydrate--or that the diet should contain no more than 4.5 to 6.0 grams of digestible carbohydrate per kilogram of trout weight per day. Quantities in excess of these levels will cause an excessive deposition of glycogen in the livers and, eventually, death.

Particular care should be taken to regulate the carbohydrate level of the diet if starchy foods are cooked, as cooking increases the digestion of the starches. Some hatcheries cook the feed mixture to obtain a bound diet, and the cooking has caused a loss of trout. Normally hatchery diets do not contain excessive amounts of digestible carbohydrate. A balance between plant and animal concentrates in the dry portion of trout diets generally will assure a low level of digestible carbohydrate.

The major sources of carbohydrate in trout diets are plant concentrates, including wheat middlings, red dog flour, oat meal, shorts, and cottonseed meal. However, if these foods are fed raw, they can be included in the diet at relatively high levels. Most animal concentrates, such as meat meals, fish meals, tankage, and blood meals, are low in carbohydrate (less than 1.0 percent). The high percentages of milk sugar in dried skim milk and dried buttermilk may cause harm if fed at levels in excess of 12.5 percent of the diet. Distiller's solubles contain a high percentage of carbohydrate in the form of pentosans, which are not utilized by trout and therefore cause no alarm. Fresh meat products contain practically no carbohydrate.

## Summary

After its absorption, carbohydrate is burned for energy and stored temporarily as glycogen or converted into and stored as fat. Trout are not equipped physiologically to handle high dietary levels of carbohydrate. Trout diets should not contain more than 9 to 12 percent of digestible carbohydrate, or the fish should not be fed more than 4.5 to 6.0 grams of digestible carbohydrate per kilogram of weight per day. Normally trout diets do not contain an excess of carbohydrate, but cooking increases the digestibility of the starches in the diet. Plant concentrates are major sources of carbohydrate in trout diets. Dried milks are animal products high in carbohydrate and should be fed within the suggested limits.

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*Carbohydrate **Protein

# SALMON STRIPPER, EGG COUNTER, AND INCUBATOR

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THE HYDROELECTRICAL SCHEMES FOR THE SWEDISH RIVERS EMPTYING INTO THE BALTIC make those rivers inaccessible for salmonid fish migrating from the sea and impound the river water, rendering the former streams unfit for spawning and smolt production. Salmon conservation in Sweden, therefore, has to rely mainly upon the artificial production of smolt in large rearing stations.

The chief species under consideration are Atlantic salmon (Salmo salar) and sea trout (S. trutta).

The rearing station at Bergeforsen, in the mouth of the Indalsälven River, has been planned for a capacity production of about 400,000 smolt per year. The large-scale operations of this "salmon plant" demand intensive mechanization in order to reduce the need for expensive manual labor. For stripping the parent fish, for counting and incubating the eggs, the devices described here are now in use.

## Stripping the Females

The Atlantic salmon does not die after spawning, nor does the sea trout. It is not necessary, therefore, to secure the eggs from killed fish, as seems to be the practice with species of the genus Oncorhynchus (Hagen 1953). The method commonly adopted in Sweden is the same as that described by Davis (1953). The handling of a large live salmon, however, is not so easily performed by a single operator and may take some time.

The first step in our new practice is to put the female fish into a double-walled rubber sack (figure 1). The tail of the fish, left protruding just to the anus, is held by the operator (figure 2). The sack can be raised in a holder so as to fit the fish closely. The space between the walls of the sack is connected with the water piping. With his free hand, the operator turns the tap. Now water is allowed to enter between the walls under appropriate pressure. The inner rubber wall presses against the whole fish; and it--if in the right stage of ripeness--readily releases the eggs, which fall into a perforated jar. The work is easily performed by one man. The female struggles less during this kind of handling and seems to recover more rapidly than when the ordinary method of stripping is used.

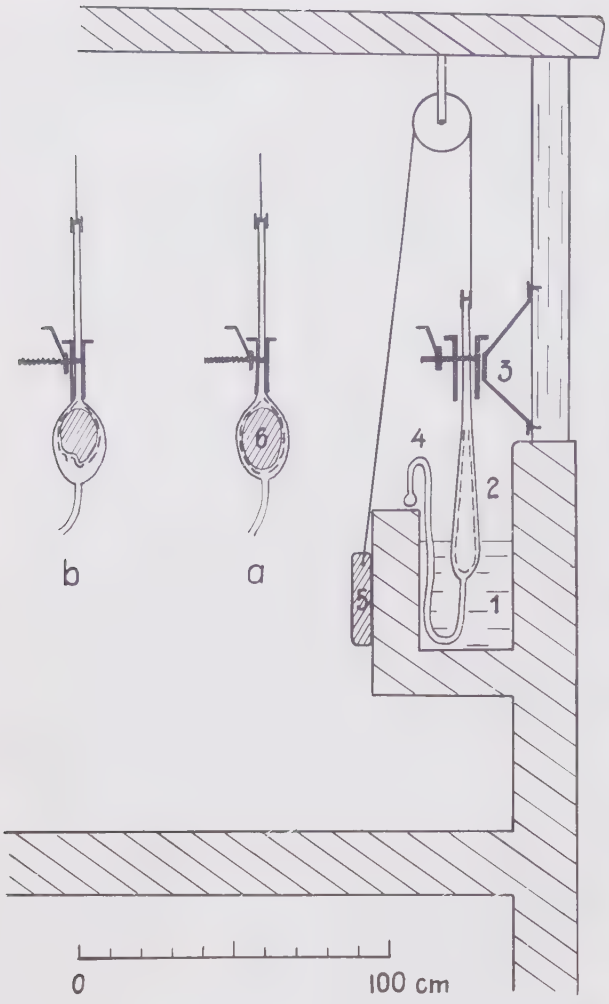
## Stripping the Males

For quick work it is convenient to have the milt stored in test tubes instead of fertilizing directly with one or more male fish.

The male is placed upside down in a holder which covers the forepart of the body. By gentle pressing movements, the milt is caused to emerge. It is immediately sucked into a glass tube connected to a jet suction pump and held like a pencil (figure 3). Pure milt is easily secured and can be stored for several fertilizations. At low temperatures, storage for days is possible (Brofeldt 1914, Lindroth 1942).

## Counting the Eggs

Diverse methods of counting the eggs of salmonids are in use (Burrows 1951).




(Illustrations courtesy of the author)

FIGURE 1.-- A section of the salmon stripper ready to receive a fish; details of the rubber sack holding the fish before (a) and after (b) stripping.
(1) Concrete conduit from fish tank, (2) double-walled rubber sack, (3) iron stand, (4) water pipe, (5) counterweight.

FIGURE 2.--A female salmon being stripped.

FIGURE 3.--Sampling the milt from a male salmon.

In the Scandinavian countries, aside from calculations based upon countings of small weighed or measured samples, the so-called Brofeldt method has found wide distribution (Brofeldt 1935). This method is based upon a measure of the stretch occupied by 10 eggs in a row; a table giving the number of hardened eggs per liter has been developed. Lately exact counting has been done by means of counting plates with holes--the holes numbering to some hundreds. Such a plate is submerged in the egg jar, which is sometimes made to fit the plate.

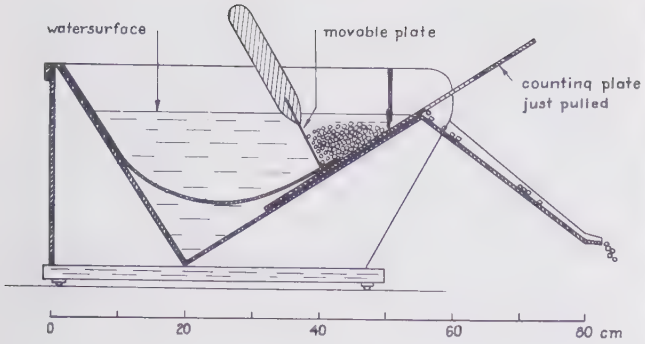



FIGURE 4.--A section of the egg counter, movable type.

An egg counter (figures 4 to 6) is used to charge an incubator that has sections containing 100 eggs each. The construction of the plastic counter is evident from the drawing and photographs. The essential part, the counting plate with its 100 holes, is exchangeable to fit the size of the eggs. The original counter (figure 6) was operated by one man, while another man moved the egg tray to be charged as the sections were filled with exactly 100 eggs. In a new model, which will be put into use during the coming season, the counter is movable on a table, the tray is fixed, and the labor of one man is saved (figure 7).

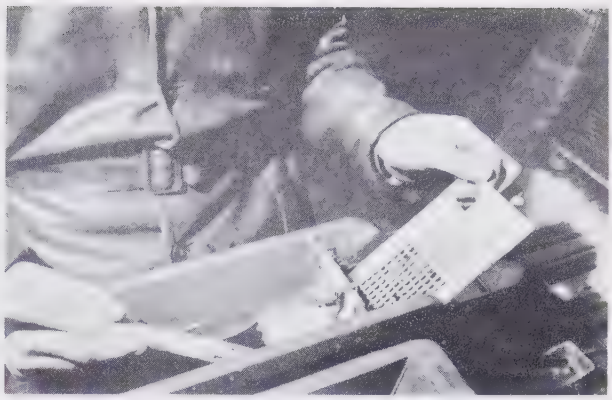
The apparatus has been operated at a speed of 1,000 eggs or more per minute by a trained operator. It may be possible to count still faster if the distribution of eggs on trays is omitted. Yet, though accurate, the method is considerably slower than the diverse sampling methods.

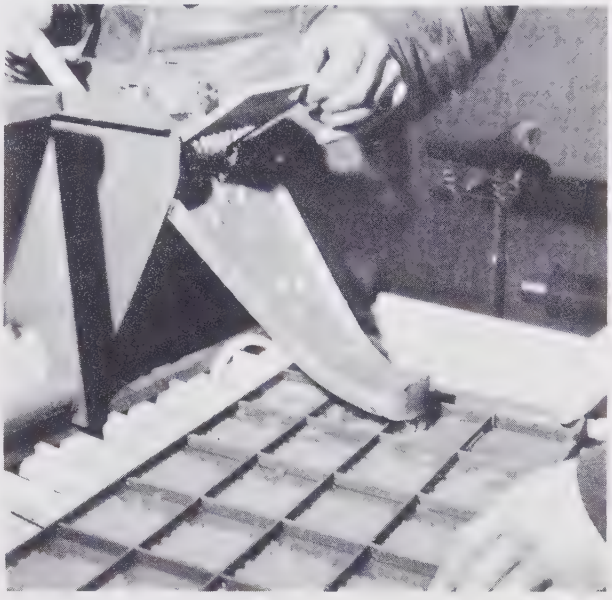
Opposite

FIGURE 5.--The counting plate, just before being put under the eggs.

FIGURE 6.--The counting plate being raised, and the 100 eggs gliding into their section in the tray, which is moved by an assistant.

FIGURE 7.--The new model, worked by one man.





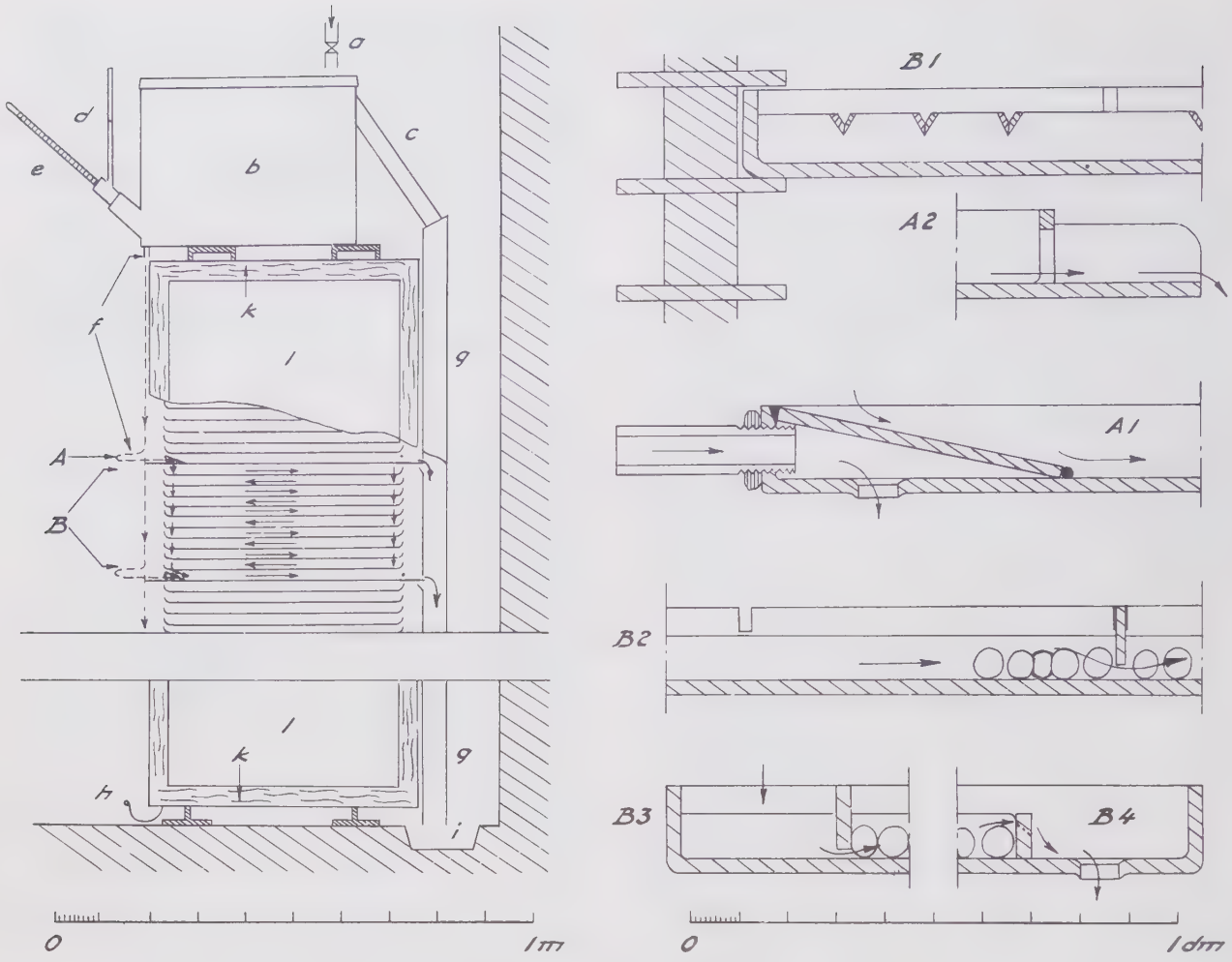



FIGURE 8.--Side view and section of the tray incubator. (a) Inlet maximum, 15 liters per minute; (b) water tank; (c) overflow; (d) surface index; (e) thermometer; (f) plastic tubing to water trays, maximum, 1 liter per minute per 10 egg trays; (g) spout; (h) gutter; (i) outlet conduit; (k) wall frame, (l) wall; (A) water tray; (B) 10 egg trays.

Details: (A1) Inlet end; (A2) outlet end of water tray; (B1) transverse section of egg tray and part of wall (built of plastic strips and staves in the iron frame, k), showing the overflow edge of the tray; (B2) longitudinal section of egg tray, showing the detachable transverse partitions; (B3) inlet end; (B4) outlet end of egg tray.

## The Tray Incubator

In Sweden salmonid eggs are usually incubated by means of a basket method, called the Californian method (Nordqvist 1922), in which some 10,000 eggs are placed in wooden boxes fed with water through a wire-netting bottom. Incubating 1 million eggs requires a floor area of about 100 square meters. As a rule, the eggs from different females are mixed in the boxes. Dead eggs cannot be picked in the susceptible egg stage. The water requirement is about 5 liters per second at hatching. The fry may be kept in the boxes during the whole sac-fry stage.

Swedish fish-culturists have performed experiments to devise a technique more saving of space--such as the technique involving the drip incubator (Oquist 1952),

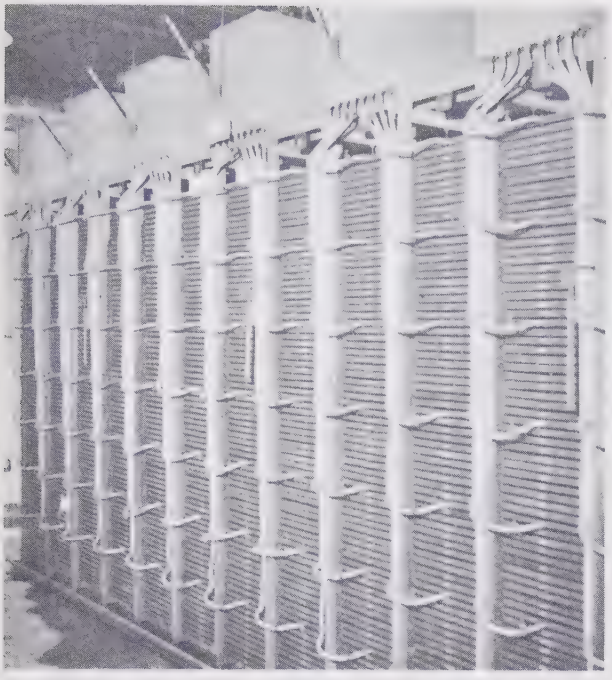


FIGURE 9.--In the 11 visible piles, 1,770,000 eggs are accommodated.

FIGURE 10.-- Emptying one section of eggs. This may be necessary when eggs from two females are on the same tray. Otherwise, the whole tray is turned over in a net.

which resembles the incubator described by Davis (1953). At this station the tray incubator is now in use.

The essential detail of the tray incubator is a plastic tray, 54 by 30 by 1.5 centimeters, divided into 24 sections that hold 100 eggs each. The trays are tightly piled between plastic walls and are moved smoothly on slides. Each pile contains 70 egg trays. Between every 10 trays there is 1 special water tray that feeds the 10 trays below and serves as outlet for the 10 trays above. Further details are shown in figures 8, 9, and 10.

The tray incubator saves space and water: a meter along the room wall will accommodate 3 piles of 70 trays each, or 504,000 (3 x 70 x 2,400) eggs; 1,000,000 eggs will require less than 1 liter per second of water. The trays are easily picked, even during the susceptible stage of the eggs, but probably it will prove to be more economical to treat with fungicides as well. The eggs of different females are kept apart, the first lot of 100 eggs of a new female being marked by a numbered piece of white plastic.

The main disadvantage of this type of incubator is that actual hatching is not conveniently done on the shallow trays. Yet, the Swedish experiments, especially at the pilot plant at the Hölle laboratory, indicate the usefulness of a special fry trough where the alevins learn to feed in artificially warmed water before they are moved to the larger rearing troughs (Carlin 1956). In this small trough the hatching of the eggs is accelerated among stones that are later removed. Where this technique is excluded, the trays may be made deeper--in which case the apparatus will resemble the vertical incubator newly described by Burrows and Palmer (1955).

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## NONBREAKABLE SAMPLE BOTTLES FOR WINTER OXYGEN DETERMINATIONS

The ordinary D.O. bottle, subject to freeze-breaking, has been a source of annoyance to many fishery workers given the task of making winter oxygen determinations. Having experienced considerable inconvenience and frustration while using this bottle, James M. MacMartin of the Vermont Fish and Game Service lately sought and found a satisfactory substitute among the new polyethylene plastic bottles now on the market.

"Plenty of bottles were available," writes Mr. MacMartin from his office in Montpelier, Vermont, "but all of them had screw caps, and none of them had the exclusion-type stopper necessary for this work. Then someone remembered that in bacteriological work an elongated, tapered rubber stopper is used in serial-dilution bottles, which have to be autoclaved with the stopper and the contents in place.

"It developed that the Escher stopper was a perfect fit for an 8-ounce polyethylene (Nalgene) bottle and, during the sampling procedure, acted perfectly to exclude any stray air bubbles from the sample.

"Number-headed tacks placed in the stopper make it easy to keep samples in order. The smaller size of this bottle doesn't matter because the procedure becomes quantitative only after the aliquot has been taken for titration. Our practice has been to use half the normal aliquot and therefore to double the titration value to get the oxygen in terms of parts per million.

"These bottles have proved to be invaluable in winter oxygen sampling done this year, and it is proposed to use them during all seasons, for they are impervious to impact damage."

# FARM-POND INVESTIGATIONS IN ALABAMA

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DURING THE FALL AND WINTER OF 1952 AND THE SPRING OF 1953, a total of 106 farm ponds, their sizes ranging from 0.5 to 25 acres, were stocked with bluegill (Lepomis macrochirus), shellcracker (L. microlophus), and largemouth bass (Micropterus salmoides). Efforts were made to stock all ponds with a combination of 1,000 bluegill and shellcracker fingerlings and 100, 125, or 150 bass fingerlings per acre. Fish population studies were conducted in all of the ponds during the summer of 1954 and again in most of the ponds during the summer of 1955.

The objectives of this investigation were to determine which of the bass stocking rates used resulted in the greatest number of successful ponds, and to determine as closely as possible the major factors or conditions which resulted in unsuccessful or unbalanced ponds.

## Procedure

The ponds used in this investigation were selected from fish applications received from pond owners in three counties which were in northern, central, and southern Alabama. For this study, there were used only those ponds which, the owners indicated, would be fertilized and did not contain fish. Also, the individuals' estimates of their pond acreages, as checked and approved by State conservation officers, were used to determine the total number of fish to be stocked in each pond.

The individuals were not aware that their ponds had been selected for this investigation and, after they received their fish, were not contacted until the ponds were checked during the summers of 1954 and 1955. However, the pond owners were provided--as are all individuals who request fish--with information stressing the importance of eradicating wild species before stocking hatchery fish, of using proper fertilization, and of abstaining from fishing until the originally stocked bass have spawned for the first time.

All ponds were stocked with a combination of 1,000 bluegill and shellcracker (approximately 85 percent bluegill and 15 percent shellcracker) fingerlings per acre for the acreage as listed on the fish applications. These fish were stocked from October 1952 through April 1953, and they ranged from 1 to 3 inches in length. One-inch fingerling bass were stocked in all ponds during April, May, or June, 1953, approximately equal numbers of ponds of comparable size being stocked at rates of 100, 125, and 150 fingerlings per acre. These rates of stocking were found by Swingle (1951) to be satisfactory for fertilized ponds in the Southeast.

During the second summer after stocking, State fishery biologists checked each of the ponds to determine the condition of their fish populations. In general, the fish populations were examined by the method originated by Swingle (1945) and were subsequently classified as to degree of balance as suggested by Swingle (1950).

Basically all ponds were considered to be either successful or unsuccessful. The successful group included ponds that provided satisfactory fishing; this group consisted of ponds containing crowded bass

populations and ponds that were in balance. On the other hand, the unsuccessful classification included all ponds that did not provide satisfactory fishing; such ponds contained overpopulations of bluegill or competitive species of fish. All the ponds that were classified as successful when checked during the summer of 1954 were rechecked during the summer of 1955.

During the biologist's visit, detailed information concerning the management--or the lack of management--of the pond was obtained from the pond owner. Emphasis was placed on obtaining accurate data concerning the actual area of the pond, the eradication of wild species of fish prior to stocking with hatchery fish, the possibility of having fish enter the pond from other waters, the fertilization of the pond, the removal of bass before spawning, and the fishing success.

## Results and Discussion

Although 106 farm ponds were originally selected to be studied, 24 of the ponds could not be used. Fish populations were not found in 9 of these 24 ponds: the fish population of 1 pond was eradicated when agricultural insecticides washed into it; 2 ponds were not stocked, although the owners received hatchery fish; fish could not be found with seines in 3 ponds; and 3 other ponds were dry. One of the 24 ponds was rated unusable because it had been stocked with hatchery fish during the 1951-52 stocking season and again, after being enlarged, during the 1952-53 season.

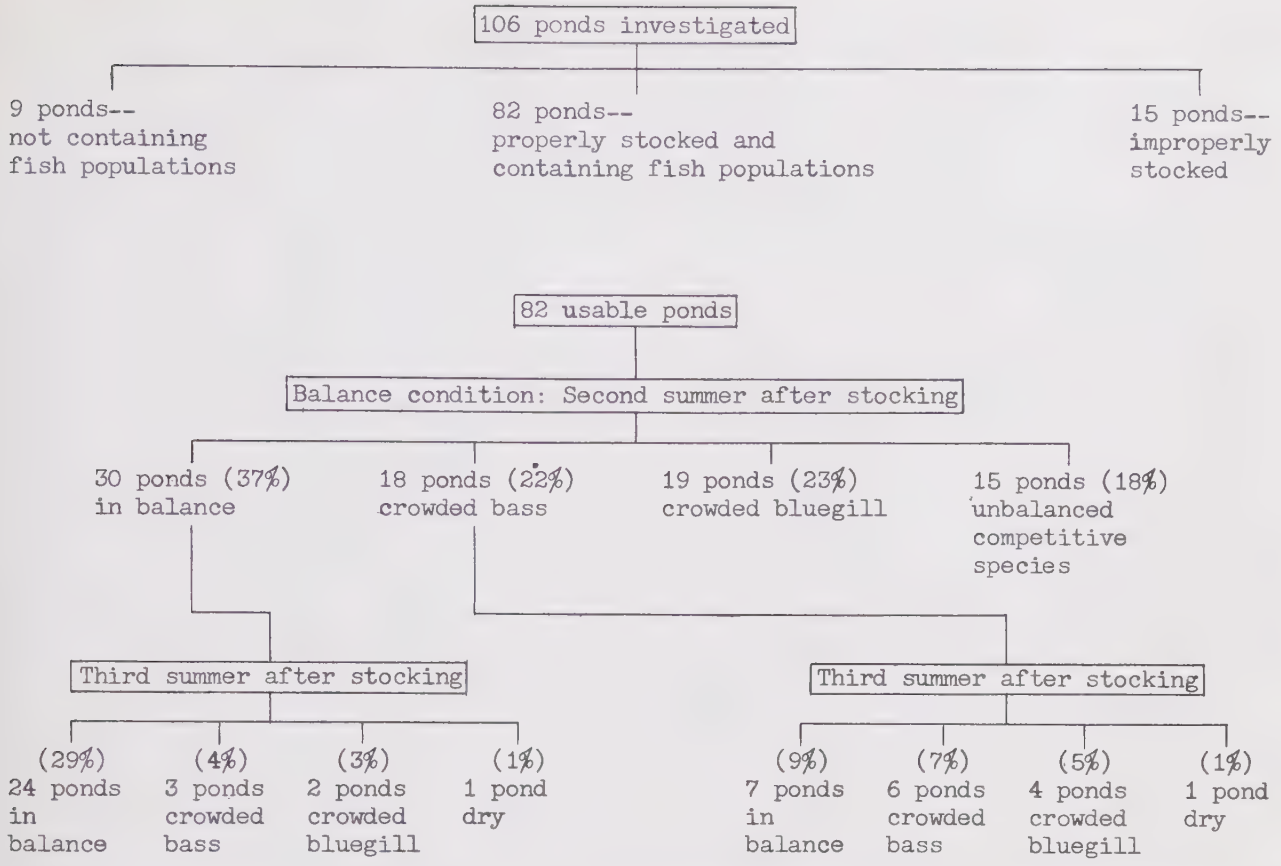
Fourteen of the 24 ponds discarded (or 13 percent of those originally selected for this investigation) could not be used because their actual stocking rates differed considerably from those that had been selected for study. This discrepancy between the actual and intended rates of stocking occurred because of incorrect acreages reported on the fish applications. For these ponds, the actual stocking rates ranged from 50 to 800 bream (bluegill and shellcracker) per acre.

It was found that among these 14 ponds, only 2--stocked with 200 and 300 bass, and 2,000 and 3,000 bream fingerlings per acre, respectively--were in balance when checked during the second summer. In the same group of 14 ponds, 7--stocked at rates ranging from 200 to 300 bass and from 1,500 to 2,000 bream per acre--contained overpopulations of bass. The remaining 5 ponds--4 stocked at rates ranging from 300 to 800 bass and from 2,000 to 8,000 bream, and 1 stocked with 50 bass and 500 bream per acre--contained overpopulations of bluegill. It is interesting to note that 64 percent of these 14 ponds were classified as successful after their initial checks, but only 28 percent remained in the successful classification after the third summer.

A total of 82 ponds, comprising about 260 acres, apparently were stocked according to the rates originally planned for the study. Fish population checks conducted during the second summer (1954) indicated that 30 ponds were in balance, 18 contained overpopulations of bass, 19 ponds contained overpopulations of bluegill, and 15 ponds were unbalanced primarily as the result of competitive species of fish (see chart).

Balance checks conducted during the third summer (1955) revealed that of the 30 ponds containing balanced populations during the second summer, 24 ponds remained in balance, 3 became crowded with bass, 2 became overcrowded with bluegill, and 1 pond was dry. When the 18 ponds that contained overpopulations of bass the second summer were rechecked a year later, it was found that 7 ponds were in balance, 6 remained crowded with bass, 4 were overpopulated with bluegill, and 1 pond was dry.

Fifty-nine percent of the 82 ponds were successful second-year ponds, whereas 49 percent were successful third-year ponds (see chart). At first it appeared that the percentage of successful ponds was rather low. However, when the ponds that were unbalanced because of overpopulations of competitive species such as green sunfish (Lepomis cyanellus) and bullheads (Ameiurus sp.) were discarded, the percentage of successful ponds was increased to 72 percent for second-year and to 60 percent for third-year ponds.


106 ponds investigated
9 ponds-- not containing fish populations
82 ponds-- properly stocked and containing fish populations
15 ponds-- improperly stocked
82 usable ponds
Balance condition: Second summer after stocking
30 ponds (37%) in balance
18 ponds (22%) crowded bass
19 ponds (23%) crowded bluegill
15 ponds (18%) unbalanced competitive species
Third summer after stocking
Third summer after stocking
(29%) 24 ponds in balance
(4%) 3 ponds crowded bass
(3%) 2 ponds crowded bluegill
(1%) 1 pond dry
(9%) 7 ponds in balance
(7%) 6 ponds crowded bass
(5%) 4 ponds crowded bluegill
(1%) 1 pond dry

**Balance conditions of 82 farm fishponds as determined during the second (1954) and third (1955) summers after stocking with hatchery fish**

## Analysis of Bass Stocking Rates

Of the 82 ponds that were stocked at selected rates, 26 were stocked with 100 bass per acre, 29 were stocked with 125, and 27 were stocked with 150 fingerling bass per acre. After the balance checks were conducted during the second summer, it was found that 50 percent of the ponds stocked with 100 bass per acre, 28 percent of those stocked with 125 per acre, and 33 percent of the ponds stocked with 150 per acre were in balance (table 1).

At first it appeared that the lowest rate of bass stocking was superior to the others. When the data were analyzed on the basis of successful versus unsuccessful ponds, however, it was found that there was no appreciable difference for the rates used. For example, where 100 bass per acre were used, 61 percent

TABLE 1.--The balance conditions of 82 farm fishponds during the second summer (1954) after ponds were stocked with a combination of 1,000 bluegill and shellcracker and 100, 125, or 150 bass fingerlings per acre

| Stocking rate of bass (per acre) | Balance condition | | | | Total |
|---|---|---|---|---|---|
| | Successful ponds | | Unsuccessful ponds | | |
| | In balance | Crowded bass | Crowded bluegill | Competitive species | |
| 100 | 13 | 3 | 7 | 3 | 26 |
| 125 | 8 | 7 | 7 | 7 | 29 |
| 150 | 9 | 8 | 5 | 5 | 27 |
| Total | 30 | 18 | 19 | 15 | 82 |

of the ponds were successful; where 125 bass per acre were used, 52 percent were successful; and where 150 bass per acre were used, 63 percent were successful. Therefore, it must be assumed that the variations in the bass stocking rates were not of sufficient magnitude for their results to be measured, apparently because of other variations occurring within the pond populations.

## Factors Contributing to Pond Success or Failure

The principal factors that resulted in or contributed to pond failures in this investigation appeared to be (a) the presence of wild fish in the ponds before hatchery fish were stocked, (b) the migration of wild species into ponds where precautions were taken to eliminate wild fish before stocking hatchery fish, and (c) the removal of bass before they spawned for the first time. This, in general, substantiated the findings of Swingle (1952).

### Failure To Eradicate Wild Fish Before Stocking

The major cause of unsuccessful ponds in this study appeared to be the failure of pond owners to eradicate wild fish from their ponds before stocking hatchery fish. Of the 53 ponds where precautions had been taken to eliminate wild fish, 68 percent were successful; whereas of the 29 ponds where such precautions had been omitted, only 41 percent were successful (table 2).

In this study, balance checks revealed that wild species were present in 13 of the 19 ponds in which no precautions to eliminate wild fish had been taken and into which wild fish could not migrate. Seven of the 13 ponds were unbalanced primarily as the result of the presence of competitive species of fish, and 2 other ponds in this group contained wild species which may have contributed to their overcrowded bluegill populations. Also, various numbers of wild fish were present in the 4 successful ponds in this group and may have reduced the yield of harvestable fish.

### Migration of Wild Species of Fish

Only those ponds that were treated with rotenone or that were dry before the closing of the drain valve prior to their being stocked with hatchery fish, were used in determining the significance of the migration of wild fish into the ponds.

It was possible for wild fish to migrate into 33 of the 53 ponds that apparently did not contain fish prior to stocking (table 2). Balance checks revealed that 14 of these 33 ponds actually did contain wild fish. Four of the 14 ponds into which wild fish migrated were unbalanced primarily as the result of competitive species, and the presence of wild fish in 4 additional ponds may have contributed to their overcrowded bluegill conditions. Also, the yield of fish of a usable size undoubtedly was lowered in the 6 remaining ponds into which wild fish migrated.

The criteria used in determining the possibility of fish migration into a pond were whether the pond had filled and overflowed before bass were stocked, whether the spillway was of sufficiently gradual slope to allow fish to ascend when the pond was overflowing, whether the spillway was adequately screened, and whether other waters were present in the proximity of the pond. It is probable that information on the possibility of downstream migration from old ponds into the new ponds prior to and subsequent to stocking also should have been obtained, but this was not done in the present study.

### Removal of Bass Before Spawning

One pond among the 7 unsuccessful ponds that did not contain fish prior to stocking and into which fish could not migrate, was a failure apparently because of the removal of bass before they had spawned for the first time (table 2). It should be noted, however, that all 5 ponds in which heavy fishing occurred before the bass spawned were overpopulated with bluegill. Furthermore, none of the successful ponds were fished before bass had spawned. Therefore, it appeared that the removal of bass before they spawned for

TABLE 2.--The balance conditions as determined during the second summer (1954) and major factors contributing to success or failure of 82 farm fishponds in Alabama

| Factors contributing to success or failure | | | Successful | | Unsuccessful | | Total |
|---|---|---|---|---|---|---|---|
| | | | In balance | Crowded bass | Crowded bluegill | Competitive species | |
| Ponds poisoned or were dry before impoundment | Fish could migrate into pond | Bass removed before spawning | 0 | 0 | 1 | 0 | 1 |
| | | Bass not removed--- | 13 | 10 | 5 | 4 | 32 |
| | Fish could not migrate into pond | Bass removed before spawning | 0 | 0 | 1 | 0 | 1 |
| | | Bass not removed--- | 9 | 4 | 6 | 0 | 19 |
| Ponds not poisoned or were not dry before impoundment | Fish could migrate into pond | Bass removed before spawning | 0 | 0 | 1 | 0 | 1 |
| | | Bass not removed--- | 2 | 1 | 2 | 4 | 9 |
| | Fish could not migrate into pond | Bass removed before spawning | 0 | 0 | 2 | 0 | 2 |
| | | Bass not removed--- | 6 | 3 | 1 | 7 | 17 |
| | | Totals-------- | 30 | 18 | 19 | 15 | 82 |

the first time definitely reduced the possibilities of obtaining successful ponds.

## Fertilization

Of the group of 82 pond owners who stated that their ponds would be regularly fertilized, 12 owners did not apply any fertilizer, 29 made 1 to 3 applications, 18 made 4 to 6 applications, and 23 of the owners fertilized 7 to 12 times during the first year after the ponds were stocked (table 3).

The effects of various rates of fertilization upon the balance condition could not be determined in this study because other variables were present. It is interesting to note, however, the extent of fertilization for the first and second years after stocking, as shown in table 4.

An average of 25 percent of the total number of ponds was fertilized adequately (7 to 12 times); 20 percent, moderately; and 35 percent, lightly. An average of 20 percent received no fertilizer. Smith, Kirkwood, and Hall (1955) indicated that only 6 percent of 239 ponds studied in Kentucky were fertilized adequately to maintain at least a light plankton bloom. Adequate fertilization of farm fishponds has been described by Swingle and Smith (1947) as being essential to good pond management in the Southeast.

TABLE 3.--Balance condition and fertilization records of 82 ponds for the first year (1953) after stocking hatchery fish

| Balance condition | Number of fertilizer applications[1/] None | 1-3 | 4-6 | 7-12 | Total |
|---|---|---|---|---|---|
| Successful ponds: | | | | | |
| in balance | 2 | 11 | 7 | 10 | 30 |
| crowded bass | 3 | 5 | 6 | 4 | 18 |
| Unsuccessful ponds: | | | | | |
| crowded bluegill | 3 | 8 | 2 | 6 | 19 |
| competitive species | 4 | 5 | 3 | 3 | 15 |
| Totals | 12 | 29 | 18 | 23 | 82 |

[1/] One application of the fertilizer consisted of 100 pounds of 6-8-4 and 10 pounds of nitrate of soda or their equivalent for each acre of water.

TABLE 4.--Extent of fertilization for the first and second years after stocking

| Number of fertilizer applications | Percentage of ponds fertilized: First year (1953) | Second year (1954) |
|---|---|---|
| 7 to 12 | 28 | 22 |
| 4 to 6 | 22 | 19 |
| 1 to 3 | 35 | 35 |
| None | 15 | 24 |

## Size of Bream and Date Stocked

Approximately 56 percent of the ponds that were stocked with 1-inch fingerling bream (bluegill and shellcracker) were successful, as compared to 58 percent where 2-inch fingerlings were used and 71 percent where 3-inch fingerlings were used. Of the group of 82 ponds, 32, 43, and 7 ponds were stocked with 1-inch, 2-inch, and 3-inch bream, respectively.

Also, about 51 percent of 41 ponds stocked in October were successful, as compared to 20 percent of 5 ponds stocked in December, 87 percent of 15 ponds stocked in January, 57 percent of 14 ponds stocked in February, and 71 percent of 7 ponds stocked in April. None of the ponds were stocked with bream during November and March. Therefore, in this study it did not appear that the size of bream used and the months in which they were stocked materially affected the balance condition of the ponds.

## Summary

A study was made of 106 ponds where efforts were made to stock 1,000 bluegill plus shellcracker and 100, 125, or 150 largemouth bass fingerlings per acre during 1952-53. When biologists checked these ponds 1 year later, it was found that 15 ponds had been stocked improperly and 9 others did not contain fish populations.

Fish population checks indicated that 59 percent of the remaining 82 ponds were successful, whereas 41 percent were unsuccessful because of crowded bluegill populations or the presence of large numbers of competitive fish. A comparison of balance conditions of the ponds did not indicate that any one of the bass stocking rates used was superior to the others in obtaining successful ponds.

The principal factor contributing to unbalanced fish populations apparently was the presence of wild fish in the ponds prior to stocking hatchery fish. About 68 percent of the ponds were successful where precautions were taken to eliminate wild fish before stocking, as compared to 41 percent where no such precautions had been taken.

Another cause of pond failure was the migration of wild fish into those ponds where precautions were taken to eliminate wild species before stocking hatchery fish. Four of the 14 ponds into which wild fish migrated were unbalanced primarily as the result of competitive species, and the presence of wild fish in 4 other ponds in this group may have contributed to their overcrowded bluegill conditions.

Apparently the removal of bass before spawning contributed to unbalanced populations in the 5 ponds that were heavily fished during that period.

The effects of fertilization upon the balance conditions of the ponds could not be determined; however, it was found that 25 percent of the ponds were fertilized adequately and 20 percent did not receive any fertilizer.

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IOWA FISH AND FISHING, by James R. Harlan and Everett B. Speaker. Third edition, 377 pages, $2.50 postpaid from the State Conservation Commission, East 7th and Court, Des Moines 9, Iowa.

This fine edition offers text changes made throughout and nomenclature brought up to date. The 140 additional pages present a new chapter on natural baits and baiting (32 black-and-white figures), a new chapter on fishing tackle (79 black-and-white figures), a new chapter on fish distribution (98 maps), a major revision and extension of text on angling, and a new section on state-owned access to fishing waters. Nine additional color plates, presenting 39 new fish, make a total of 18 plates and 63 fish.

# FISH-ESCAWEIGHER

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Sacramento, California

THE RAPID LOADING AND ACCURATE ENUMERATION OF LARGE LOADS OF LIVE FISH have been a problem for years. With the accent on more and larger fish and longer trips, California has steadily increased the size of fish-hauling equipment. Fifteen-hundred-gallon planting tanks are now used routinely.

For many years a suspended spring scale has been used in weighing fish into a truck. A 5-gallon bucket is suspended from the scale and, when the desired number of fish has been added, is hand-lifted to the top of the tank truck. Though fairly accurate, this method is laborious and slow, especially with large loads.

In a recent development for loading catchable-size trout into tank trucks, a fish escalator is employed. The displacement method is then used to determine the number of fish loaded.

The escalator differs only slightly from a conventional flat-belt conveyor of the kind normally used in loading grain, sugar beets, or other farm products. The main difference is that the rubber belt, instead of being flat, is fitted with rubber cleats 4 inches high and spaced 9 inches apart. Powered by a 3-horsepower gasoline engine and driven by means of a series of chains and sprockets, the belt moves along at a rate of about 100 feet per minute. Constructed primarily of aluminum and mounted on two pneumatic-tired wheels, the unit is light and can easily be moved from one location to another.

When fish are being loaded, one end of the escalator projects down into the pond from which the fish are taken; the other end extends to the top of the tank truck. Fish are placed on the lower portion of the escalator with a dip net. The cleated rubber belt then carries them upward onto the planting truck, where they fall into the tank. There is sufficient leakage between the escalator belt and the support in which it runs to permit all of the water to escape before the fish reach the top. In this way, a dry weight is obtained. Even though the fish jump and evince considerable excitement, most of them ride the full journey without dropping down the escalator more than the distance of one or two cleats. No fish remains on the escalator belt more than 10 seconds. Tests have shown that fewer fish are injured by this process than when the fish are weighed, placed in buckets, and the buckets lifted onto the truck.

Because the fish are added to the tank in the dry state, the displacement method can be used to weigh the fish. This eliminates using the scale except for a sample count to determine the number of fish per pound.

The rear of the planting tank is equipped with a glass sight gauge of the type used to determine the water level in a steam boiler. Alongside the sight gauge is a strip of brass material calibrated to fit the individual truck. The brass strip is marked off in increments of 25, 50, or 100 pounds of water, depending on the size of the tank. To be as plainly visible and as fully protected as possible, the gauge and brass marker strip are installed as high as possible on the rear of the tank.

In order to calibrate the sight gauge, the following steps are taken:

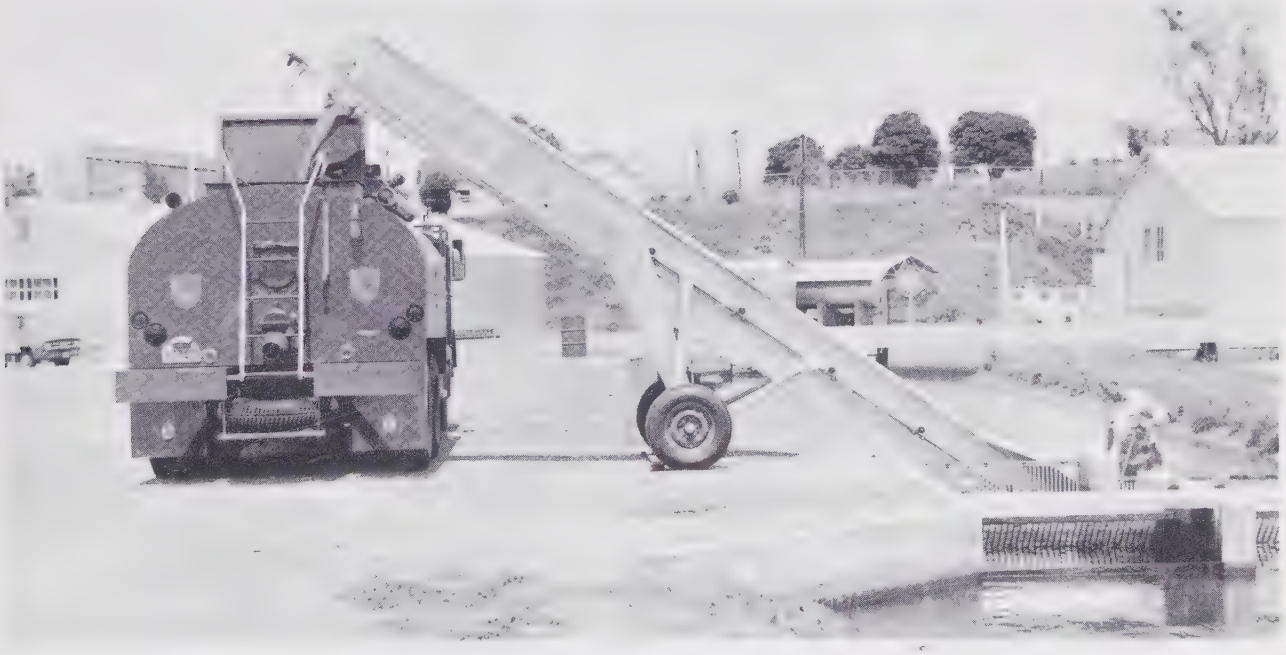
Escalator carrying away fish faster than two men can load them.

The sight gauge is mounted high on the rear of the tank.

(Photographs courtesy of the author)

(A) Fill the tank with water.

(B) Slowly draw off water till the water level in the tank is visible near the top of the sight gauge. Scribe a permanent mark on the brass strip at this point. Label this mark "Zero."



Escalator in position to load fish into 1,500-gallon planting tank.

(C) With the water level in the tank now established and marked on the brass strip, draw off water into a tub set on a platform scale in increments desired.

(D) Accurately mark increments on brass strip each time water is drawn off, and label selected marks with the proper number of pounds.

Before loading fish, the tank is filled with water well above the desired pound mark on the marker strip and the truck is driven to the location where fish are to be loaded. Water is then drawn off until the water level is exactly even with the selected mark. It is not necessary that the truck be standing in a level position if the water level in the sight gauge lines up with the starting mark on the marker strip. The escalator is then started, and loading of fish proceeds until the water level is raised to the zero mark. The tank is then filled with water, the loading operation completed.

Though the specific gravities of trout and water appear to be about the same, specific gravity tests have shown that in the size range from 1 to 16 per pound an average of 1.02 pounds of trout displaces 1 pound of water. Therefore, the total number of pounds of water displaced, multiplied by 1.02, will equal the number of pounds of fish loaded.

The escalator and the sight gauge save a great deal of time and labor. With the old scale-and-bucket method, 3 men took about 1.5 hours to load 2,000 pounds of fish. Two men can do the job in about 15 minutes by using the escalator-and-displacement method.

The rapid rate of increase of the sea lamprey will probably frustrate the efforts to save the lake trout fishery of Lake Superior. The take of spawning lampreys during comparable periods (through June 22) in 30 streams under control has been: 4,922 in 1954, 8,823 in 1955, and 15,753 in 1956. Benefits from the current program cannot be expected in less than 5 years (length of the larval life of the lamprey in streams). Long before then, however, the sea lamprey's rate of increase will produce an enormous stock of parasites for the already scarce lake trout.

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## EXCERPT: A BISEXUAL STEELHEAD

"An adult sea-run steelhead rainbow trout (Salmo g. gairdneri) having both male and female reproductive organs was caught in the South Fork of the Eel River near the town of Garberville, Humboldt County, California, on January 7, 1955... Correspondence ... revealed that the steelhead weighed eight pounds and had the superficial appearance of a male fish.

"The female portions of the two gonads differ considerably in size ..., one extending about two-thirds the length of the gonad, while the other is less than half the length of the gonad. Although the male and female portions of the gonads appear to be distinct, some eggs are embedded irregularly throughout the male tissue.

"The eggs are much smaller than one would expect to find in a sexually mature female steelhead of the same size. The testes in a normal male steelhead of the same size would more nearly approach the size of the gonads in the fish under discussion."

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Taken from "A Bisexual Steelhead," note by E. D. Gibbs of the California Department of Fish and Game, California Fish and Game 42 (3): 229-231. 1956.

# EQUIPMENT FOR DROPPING FISH

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SIX FISH-DROPPING UNITS, operated in Beaver aircraft, were used in trout-planting operations in Ontario during the spring of 1953.

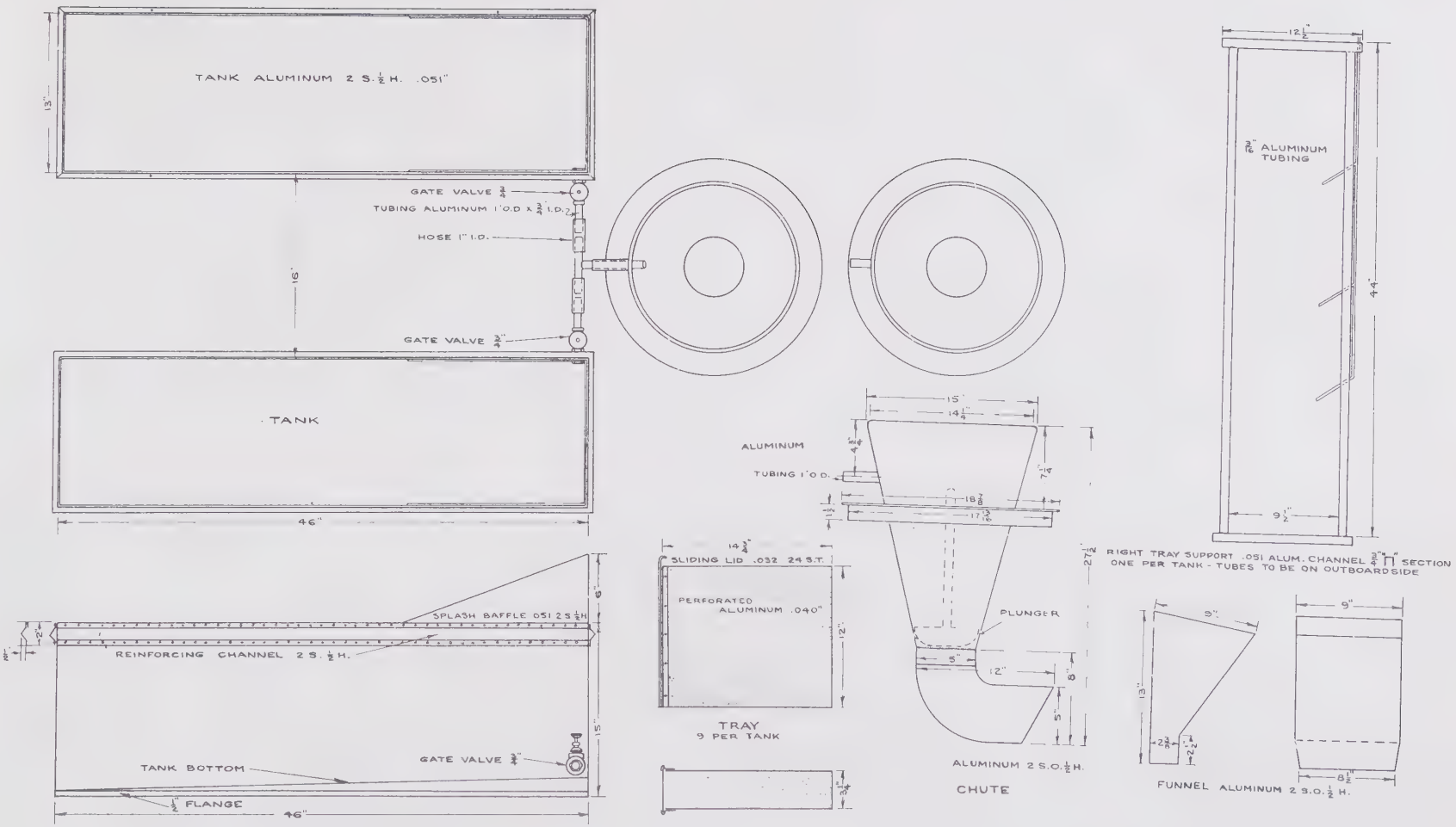
The technique and the success of planting fish by dropping them from the air are not new. Prevost (1935) described experiments in fish-dropping in Quebec, and Prevost and Piché (1939) published a detailed account of the development of equipment suitable for carrying large numbers of fish for aerial distribution. Garlick (1950) described the equipment used in planting trout from a helicopter in Olympic National Park. Leitritz (1951), working in California, described equipment used there in a C-45, a twin-engined Beechcraft.

North-central Ontario contains thousands of small lakes which are capable of growing good crops of speckled trout. Many of these lakes have no game-fish populations at the present time and do not have proper spawning facilities for trout. Such lakes are not accessible by road but have become accessible with the development of tourist camps serviced by aircraft, and with the appearance of the airborne angler. Because of the lack of roads, the establishment and maintenance of speckled trout populations in these lakes was impractical until an effective aerial planting device was developed.

In 1951, we started work in Ontario on the development of a fish-dropping unit suitable for Beaver aircraft, 37 of which are operated by the Ontario Department of Lands and Forests. Throughout this development we worked closely with very cooperative Division of Air Service personnel. The tray principle for holding the fish, as suggested by Prevost and Piché (1939), was adopted. This appeared to be the method for carrying a maximum number of fish in a given amount of water. It also provided a means of holding known numbers of fish in separate containers, thus simplifying the planting of small numbers of trout in many small lakes. The divided tank used by Garlick became twin tanks in our equipment, and the release hopper described by Leitritz became a simple light funnel. Thus our equipment consists primarily of what appeared to be the best features of apparatus used elsewhere--adapted to Beaver aircraft.

## Equipment

Tanks.--The 2 aluminum tanks are 46 inches long, 13 inches wide, and 15 inches high. A vertical splash baffle was added at the posterior sections of the tanks to avoid spilling water during the take-off surge. It will be observed (see figure) that the tank bottom was raised gradually toward the back of the tank. This feature was added to level the water in the tanks in relation to the nose-up position of the aircraft floor. This feature also reduced the minimum water requirements. The tanks were given added strength by the folded aluminum strip which was riveted around each top. In the aircraft, the tanks are placed just aft of the pilot and copilot seats and are secured to the floor by turnbuckles. A 16-inch space between tanks is sufficient for the operator, who works on his knees and faces backward in the aircraft.




Plans for fish-dropping equipment

Trays. --Nine trays in three layers of three are accommodated in each tank. Each tray is 14-3/4 inches long, 12 inches wide, and 3-1/4 inches deep, and--except for one end--is made from folded and welded aluminum that is perforated with 1/8-inch holes, the centers of which are staggered 1/4 inch apart. One end of the tray is enclosed by a sheet of aluminum which fits into horizontal grooves and provides a simple means of opening and closing the tray. Each tray can carry 500 of our yearling speckled trout, the size of which ranges from 3 to 5 inches.

Tray Support. --The tray support, made of folded sheet aluminum, is a means of supporting the trays at a height sufficient to clear the oxygen-diffusion stones. The outside sections of the supports are drilled at three points to allow passage of the aluminum oxygen tubing.

Chute. --The circular aluminum funnel, together with a standard type of lavatory plunger, constitutes a simple mechanism for holding the trout just prior to their release and for releasing them. The chute is fitted with baffle plates at the fuselage and on the cabin floor, and is accommodated in the standard camera hatch. That part of the funnel which projects below the fuselage is recurved to eliminate the tendency of the air stream to blow the water up the chute.

Oxygen System. --A Q-type of oxygen cylinder provides a source of oxygen that is adequate for several flights. In flight position, it is tied erect in the back corner of the cabin and fitted with a therapy unit which permits fine control of the oxygen flow. From the therapy unit, oxygen is carried in rubber tubing to an aluminum T-joint which gives rise to two tubes--one for each tank. These two tubes are fitted with needle valves to permit separate control of the flow of oxygen to the two tanks. At the tanks, aluminum tubing carries the oxygen to the bottom and through the tray support at three points that correspond to the positions of the three tiers of trays. Rubber tubing then provides the attachment for the three oxygen-diffusion stones. These stones are small, cylindrical, commercial carborundum products, which successfully break the stream of oxygen into fine bubbles. This method of dispersing oxygen was found to be more effective than a flow from an open tube or from a tube punctured with a series of small holes. It was found that a flow of 3 liters per minute provided adequate pressure to activate all stones and to keep the trout comfortable for as much as 1 hour.

Water System. --The water fittings on each tank are fitted with 3/4-inch gate valves that permit control of the flow of water from either tank. Rubber-hose sections, suitably clamped, and an aluminum T join the water ducts from each tank. The common flow runs aft to the chute. The water system provides a dry means of transferring water from one or both tanks to the chute before the trays of fish are dumped into the chute for release. It also provides for complete drainage of the tanks, even during the flight.

Funnel. --Although the funnel is not an essential part of the fish-dropping unit, it is a decided asset. All aluminum, it is made to fit into the end of a partly opened tray to facilitate its being filled with fish.

## Weight of Equipment

As weight and C.G. (center of gravity) considerations are of the utmost importance in aerial equipment, some measurements are presented:

| | Pounds |
|---|---|
| Tanks, 2, including gate valves | 36.00 |
| Tray supports, 2, including oxygen tubing and diffusion stones | 5.00 |
| Trays, 18 | 36.00 |
| Water system | 1.00 |
| Chute, including baffles | 6.50 |
| Turnbuckle assemblies, 6 | 2.25 |
| Q-type oxygen cylinder and therapy unit | 75.00 |
| Water (at depth of 10 inches in both tanks) | 432.00 |
| Operator | 170.00 |
| Total weight | 763.75 |

The positions and weights of these items, together with considerations of weights and C.G. positions of other standard equipment of the Beaver, including

pilot, gas, oil, and emergency equipment, are within the requirements of the Department of Transport for these aircraft when fitted with a ventral fin.

## Testing and Use of Equipment

Some test drops were made to check survival, to familiarize ourselves with the equipment, and to develop a procedure. No mortality was observed by personnel in the target area when 3- to 5-inch, and an occasional 7-inch, speckled trout were dropped. Eight lakes into which speckled trout were introduced with this equipment were checked 2 years after planting and were found to contain healthy specimens. Our survival data, therefore, confirmed those of Prevost and Leitritz.

In practice, our drops are made from 700 feet. (This altitude is varied as terrain, wind conditions, and target size dictate.) We experienced little difficulty in striking a canoe with fish from 500 feet after some practice runs. At this height the average rate of fall of 3- to 5-inch speckled trout was 15 miles per hour and the trout struck a water surface about 200 feet long and 100 feet wide.

The capacity of the aircraft for carrying fish has been increased from 3,000 to 9,000 through the use of the new equipment. Formerly, when standard fry cans were used, we were limited by the weight of water and metal--and to lakes large enough to accommodate a Beaver landing. When efficiently operating from retainers strategically based throughout the district, we are able to plant as many as 60,000 yearlings in as many as 60 lakes per day.

Most of our flights were less than an hour long. Occasional 2-hour flights apparently did not affect the trout adversely, although there was some slime formation. On rare occasions when high air temperatures caused us some concern, ice placed on top of the trays in each tank prevented any mortality.

## Advantages of Equipment

Trout can be planted immediately after the spring breakup when water temperatures are most suitable.

The time required for planting trout has been reduced from 2 months to 2 weeks.

We now have complete supervision of our planting, whereas formerly many fish had to be turned over to the public.

Air drops allow the selection of the best planting sites within lakes.

When costs are computed on the basis of $50 per hour for aircraft use, this type of fish distribution is more economical than the trucks and manpower necessary for comparable distribution on our roads and trails.

Any lake can now be effectively planted, with the result that our fishing acreage has been markedly increased.

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The University of Louisville (Kentucky) now has an endowed chair of conservation.

# RATE OF FIN-CLIPPING

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THE PREPARATION OF THIS NOTE was stimulated by the following statements in "Fishery Science" by Rounsefell and Everhart (1953: 287):

> The estimates of time required to mark fish vary widely. After marking several hundred thousand we find that many estimates are extremely optimistic. When one does nothing else but mark (someone else does the weighing, catching, removal of fish, etc.), a rate of 300 fish per hour is a very respectable rate if the fish are of a convenient size, about 3 to 5 inches. Women may attain and maintain up to 400 fish per hour, but many men never exceed 300.

Some of the phases of the fishery research program at Cornell University during the past 15 years have involved fin-clipping. In this period, 700,000 fish--including brook, brown, rainbow, and lake trout, landlocked salmon, and smallmouth bass--have been marked. It has been customary to record the marking time of the staff and graduate students detailed to this activity, and some pertinent figures on fish marked in the past 5 years are presented here.

The rate of marking fingerling lake trout (3 to 3-3/4 inches), using a single fin clip, is given in table 1. The average number of trout marked per hour in that operation ranged from 650 to nearly 950. Table 2 presents the rate of marking for yearling lake trout (5 to 6 inches), using a double clip. The marking rate in that project ranged from 340 to 540. In these operations, carried out at one New York State fish hatchery, hatchery personnel transferred the fish to the marking site and removed the marked fish. Markers dipped their own fish. The time out for breaks of a few minutes, usually every hour, is included in the marking time. No female students were involved.

Other examples of over-all average marking rates are shown in table 3.

Marking personnel have consisted of one or two permanent staff members and two to four graduate students. Usually only one of the students was a green hand, and usually he accounted for the low end of the range of rates shown in tables 1 and 2. As in any other activity, some individuals attained or possessed an adeptness resulting in a rapid rate of marking. Fin-clipping 900 to 1,000 fish an hour means clipping 1 fish about every 4 seconds. Speed in marking does not necessarily imply sloppy or careless excision of fins. Rapid marking is a combination of efficiency and deftness of movement, convenience of working quarters, and proper instrumentation.

Fin-clipping is most conveniently conducted in a hatchery trough at waist height. In our work, a holding net with a shallow bag is used to confine fish during the marking (see figure). The frame of the net fits a standard hatchery trough, and the webbing has enough belly to submerge 2 or 3 inches (deeper for large fish). Fish crowded into the holding net are quickly exhausted and cease struggling. Perhaps a mild anesthesia results from the buildup of carbon dioxide.

Some workers have found that the use of an anesthetic is helpful in fin-clipping.

TABLE 1.--Rate of marking fingerling lake trout (average length, 3 to 3-3/4 inches), using a single fin-clip

| | Fins clipped | | | | |
|---|---|---|---|---|---|
| | Right or left ventral | Adipose | Left pectoral | Right pectoral | Left ventral |
| Total fish---------- | 40,000 | 40,000 | 40,160 | 40,200 | 40,459 |
| Total time (hours)----- | 61 | 42-1/2 | 60-1/2 | 48-1/4 | 50 |
| Fish per hour---------- | 656 | 941 | 664 | 833 | 809 |
| Range---------- | 525 - 697 | 839 - 1,058 | 393 - 877 | 754 - 945 | 583 - 943 |

Eschmeyer (1953) presented evidence indicating that ether improved the marking rate from about 280 per hour to 420 (clipping the adipose and a pelvic fin). He also noted (1953:82), "The use of ether appeared to help the poorer operators most." Our experience is that a drug is most helpful when the fish are small (less than 3 inches) or unusually large (9 inches or more). The operation of dipping a few fish at a time from the hatchery trough to the vessel containing the anesthetic is time-consuming, and drugged fish lose orientation.

Many fish confined in a marking net become oriented with the current in a hatchery trough. This aids rapid fin-clipping because the motions of picking up fish tend to be standardized. Instructions for inexperienced markers discourage manipulation of fish in the hand into a marking position. Instructions stress reaching for fish that will be properly oriented in the hand as they come from the water. This one feature has more to do with efficiency in fin-clipping than any other feature. Note, for example, that Foster (1941) observed that five or six drugged fingerlings could be marked in the time usually spent in maneuvering a single fish into position.

After the clip is made, the marking hand punches the tally as the holding hand reaches into the net for a new victim. Tallying should not consume any extra time in the sequence of movements. The general setup is illustrated in the figure. Good lighting is obviously essential.

A light glove on the holding hand is sometimes an aid in holding fish, particularly for beginners or for large fish. With increased skill in handling fish, many workers discard gloves. Some of the workers employed by Eschmeyer (1953) followed this pattern. Gloves become loaded with mucus and make frequent cleaning necessary. Use of lanolin or a similar preparation on the hands adds to the comfort of the worker, particularly in cold water.

A worthwhile precaution with double clips: do not work directly over the trough receiving marked fish. A trough at which fins are clipped should hold unmarked fish

TABLE 2.--Rate of marking yearling lake trout (average length, 5 to 6 inches), using a double fin-clip

| | Fins clipped | | | | |
|---|---|---|---|---|---|
| | Left pectoral and adipose | Right pectoral and adipose | Right ventral and adipose | Left ventral and adipose | Left pectoral and adipose |
| Total fish---------- | 8,050 | 8,100 | 5,193 | 8,090 | 8,100 |
| Total time (hours)---------- | 17-1/2 | 24 | 12 | 17-1/2 | 15 |
| Fish per hour---------- | 460 | 338 | 433 | 462 | 540 |
| Range---------- | 345 - 536 | 208 - 424 | 231 - 576 | 392 - 659 | 215 - 778 |

(Photographs courtesy of the author)

A convenient setup for marking fish.

Above.--The actual clipping.

Below.--Reaching for a new fish and punching the tally at same time. The latter movement should be automatic, all visual attention being directed to picking up a new fish (tadpoles not usually clipped).

so that if a fish escapes with only one clip made, the individual will ultimately be recovered and given the full mark. Partially clipped fish in with the main lot may mean confusion later or laborious sorting.

TABLE 3.--Over-all average marking rates for rainbow and brook trout and smallmouth bass

| Species | Length in inches | Fin marked | Number per hour |
|---|---|---|---|
| Rainbow trout---- | 5 - 6 | Pectoral | 560 |
| Do.---------- | 5 - 6 | --do.--- | 626 |
| Do.---------- | 2 - 3 | Ventral | 506 |
| Do.---------- | 2 - 3 | Pectoral | 333 |
| Brook trout------ | 5 - 6 | Adipose | 748 |
| Smallmouth bass-- | 2 - 3 | Pectoral | 580 |
| Do.---------- | 2 - 3 | --do.--- | 610 |

The most efficient marking instruments appear to consist of surgical bone-cutting forceps. The writer was introduced to these by Dr. C. M. Mottley and Dr. H. J. Rayner. Bone-cutting forceps are expensive, as compared with scissors ($7 to $10 a pair), but they are much easier to work with and make a cut cleaner and closer to the body. The most useful size has a straight 13/16-inch cutting edge and an over-all length of 6 inches. For fish 9 to 10 inches in length, a larger pair with cutting edge of 1-5/16 inches and over-all length of 7-1/2 inches stands the strain better. These instruments may be obtained at hospital-supply houses. A small forceps with a 9/16-inch cutting edge was available before World War II under the brand name of "Welkut." This was a very useful size, and we should be interested in learning whether anyone knows where this forceps may be obtained currently.

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# THE IMPORTANCE OF SIZE GROUPING IN POPULATION ESTIMATES EMPLOYING ELECTRIC SHOCKERS

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DURING RECENT YEARS ELECTRIC SHOCKERS have become widely adopted by fishery workers for studies of fish populations. In many situations electric shockers will collect fish while nets and seines are ineffective. One of the principal advantages of electrofishing lies in the fact that it is much less selective than seines or nets. All sizes of all fish species are vulnerable to electric fishing gear, though a difference in vulnerability exists between different sizes and species. Cooper (1952), Schuck (1948), and Holton and Sullivan (1954) have pointed out differences in collecting efficiencies for different sizes of trout and warm-water species. The purpose of this paper is to demonstrate further the type and extent of selective fish harvest by electric fishing gear in streams.

For the past 4 years biologists in West Virginia have been employing electrofishing techniques in making population studies in streams. The work was made possible by the Federal Aid to Fish Restoration program and was an integral part of West Virginia's first Dingell-Johnson project.

When a population study was being conducted, the first step was to divide the stream section into ecological units. In general, the boundaries of a unit were located where the stream gradient changed abruptly. Units to be studied were blocked at both ends with nets prior to the collection of any fish. The electric-power unit employed was a 2,500-watt, 230-volt D. C. generator (as described by Rayner, 1949). One or two shocking trips were made through the area, and all the fish encountered (other than small cyprinids and darters) were collected. All fish were marked by fin-clipping and then released. Before recapture began, the fish were given overnight to redistribute themselves among the unmarked population. On the following day one or two shocking trips were made. The numbers and weights of marked and unmarked fish collected were recorded, and the total population was calculated by direct proportion. For a detailed description of methods, see Holton and Sullivan (1954).

In table 1 are listed the average percentages of recapture of fish from three streams. In determining these percentages, all sizes of each species have been combined.

Though the collecting effort expended in each stream listed in table 1 was not necessarily equal, there nevertheless appears to be a very definite correlation between high percentage of recapture and narrow width of stream. Extra difficulties that are encountered while shocking big water make the reason for this correlation obvious.

As might be expected, the species most difficult to capture are those generally found in places having the most cover. Bullheads and centrarchid species frequent rocky places with undercut banks, tree roots, and other cover, and are more difficult to capture than suckers and fallfish, which require little cover other than depth.

TABLE 1.--Percentages of recapture of various species by means of electric shockers in three West Virginia streams

| Stream | Average width (feet) | Percentages of recapture | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Small-mouth bass | Rock bass | Yellow-belly sunfish | Blue-gill | Green sun-fish | Bull-head | White sucker | Hog sucker | Fall-fish |
| Lunice Creek | 38 | 53 | 52 | 43 | 62 | 43 | 30 | 77 | 68 | 64 |
| Lost River | 60 | 44 | 45 | 28 | ----- | ----- | ----- | 68 | 68 | 61 |
| South Branch | 97 | 36 | 40 | 37 | ----- | ----- | ----- | 41 | 32 | 40 |

In table 2 the species listed in table 1 have been divided into size groups and the percentages of recapture have been reported for each group. The upper and lower limits of each of the size groups were reached through trial and error and, though not necessarily the optimum, were adequate for project needs.

TABLE 2.--Percentages of recapture of different size groups of various fish species by means of electric shockers in three West Virginia streams

| Species | Size group in inches | Lunice Creek | | Lost River | | South Branch | |
|---|---|---|---|---|---|---|---|
| | | Percentage of recapture | Size of sample | Percentage of recapture | Size of sample | Percentage of recapture | Size of sample |
| Smallmouth bass | ( 2.0 - 4.4 | 44 | 1,357 | 31 | 846 | 26 | 108 |
| | ( 4.5 - 8.9 | 60 | 2,138 | 51 | 1,292 | 50 | 80 |
| | ( 9.0 - Up | 62 | 305 | 67 | 93 | 31 | 16 |
| Rock bass | ( 2.0 - 4.4 | 47 | 676 | 33 | 1,171 | 29 | 58 |
| | ( 4.5 - Up | 54 | 1,014 | 53 | 1,746 | 43 | 176 |
| Yellowbelly sunfish | ( 2.0 - 4.4 | 40 | 1,310 | 22 | 315 | 36 | 22 |
| | ( 4.5 - Up | 46 | 718 | 33 | 407 | 37 | 27 |
| Bluegill | ( 2.0 - 4.4 | 60 | 58 | ---------- | ------ | ---------- | ------ |
| | ( 4.5 - Up | 64 | 68 | ---------- | ------ | ---------- | ------ |
| Green sunfish | ( 2.0 - 4.4 | 41 | 262 | ---------- | ------ | ---------- | ------ |
| | ( 4.5 - Up | 54 | 63 | ---------- | ------ | ---------- | ------ |
| Bullheads | ( 2.0 - 3.9 | 31 | 342 | ---------- | ------ | ---------- | ------ |
| | ( 4.0 - Up | 30 | 538 | ---------- | ------ | ---------- | ------ |
| White sucker | ( 2.5 - 6.9 | 33 | 18 | 37 | 155 | 27 | 62 |
| | ( 7.0 - 10.9 | 70 | 205 | 71 | 223 | 43 | 160 |
| | (11.0 - Up | 83 | 322 | 82 | 309 | 43 | 253 |
| Hog suckers | ( 2.5 - 6.9 | 65 | 616 | 57 | 97 | 16 | 43 |
| | ( 7.0 - 10.9 | 71 | 605 | 71 | 279 | 37 | 68 |
| | (11.0 - Up | 62 | 69 | 71 | 114 | 37 | 60 |
| Fallfish | ( 2.5 - 6.9 | 38 | 42 | 48 | 184 | 10 | 29 |
| | ( 2.5 - 10.9 | 67 | 149 | 75 | 144 | 31 | 39 |
| | (11.0 - Up | 90 | 21 | 93 | 15 | 72 | 39 |

From table 2 it is apparent that small fish are generally more difficult to capture than large fish. This is especially true for the suckers and fallfish, which frequent open water and are thus more vulnerable.

One reason for the higher efficiency in collecting big fish is simply that their larger size makes them more easily seen. A notable exception to this are bullheads. Nearly all bullheads are taken from under rocks or banks, and apparently any increased efficiency due to size is negated by the fact that the larger fish seek denser cover. In general, the percentages of recapture for size groups of species associated with dense cover are less diverse than the percentages for the open-water species.

## Discussion

If all sizes of a species are combined in estimating populations by mark and recovery, numbers and weights of small fish will be underestimated and those of large fish overestimated. In dealing with numbers alone, the errors would tend to compensate for each other. However, if total weight were desired, the much greater weight of large fish would far overbalance that of small fish and make the resulting estimate too high.

From table 2 it can be seen that there is no necessity for dividing bullheads into size groups, nor for dividing hog suckers into more than two groups. In certain other situations, such as in small shallow streams, it may be possible or even desirable to combine other size groups.

In the study of some areas, certain size groups are represented by only a very few fish. In such situations it is better to combine the size groups and accept the very slight error that is thus incurred in order to obtain the added accuracy that results from dealing with a large sample.

Though this study dealt with direct current, under similar conditions a like reaction was noted while using alternating current.

## Summary

1. These statistics were collected during 4 years of stream fish population study employing electric fish shockers. The work was an integral part of West Virginia's first Dingell-Johnson project.

2. Species such as bullheads and most centrarchids, frequenting areas with abundant cover, are more difficult to collect with shockers than are suckers and fallfish, which lack these cover requirements.

3. Electric shockers collect a higher percentage of large fish than of small ones. The increased efficiency in catching larger fish is due, in part, to their being easier to see once they have been shocked.

4. In mark-and-recapture population estimates, the division of most species into size groups will prevent a large overestimate of total weight.

5. In small streams or in areas where size groups are represented by only a few fish, it may be possible or even profitable to combine size groups in order to take advantage of the accuracy obtained when dealing with larger numbers.

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# A COLLAPSIBLE LIVE-CAR FOR FIELD USE

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THE PROBLEM OF HOLDING LARGE NUMBERS OF FISH ALIVE during population surveys on trout streams required that some sort of live-car be used. The limited vehicle space and the frequent necessity to hand-carry the equipment to remote stations indicated that the live-car would have to be small, collapsible, and compact. Durability in transport and hard use, as well as economy in construction, were also important considerations.

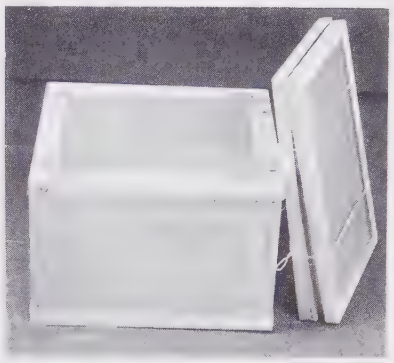
Among the possible materials for making live-cars, a "do-it-yourself" aluminum appeared to offer the greatest advantages in lightness, rigidity, and wearability. The variety of aluminum construction items available on the market and the ease with which they are worked into fabrications constituted additional advantages.

Three aluminum live-cars which averaged 2.3 cubic feet in capacity, were built and used extensively in the field during 1954 and 1955. They have proved very satisfactory in every respect. Several hundred trout and other fish have been held in individual live-cars for 2 to 3 hours with no ill effects whatsoever. The convenience afforded by these pieces of equipment during chemofishing or electrofishing operations has been great. Their design also makes them readily collapsible and easy to carry or store.

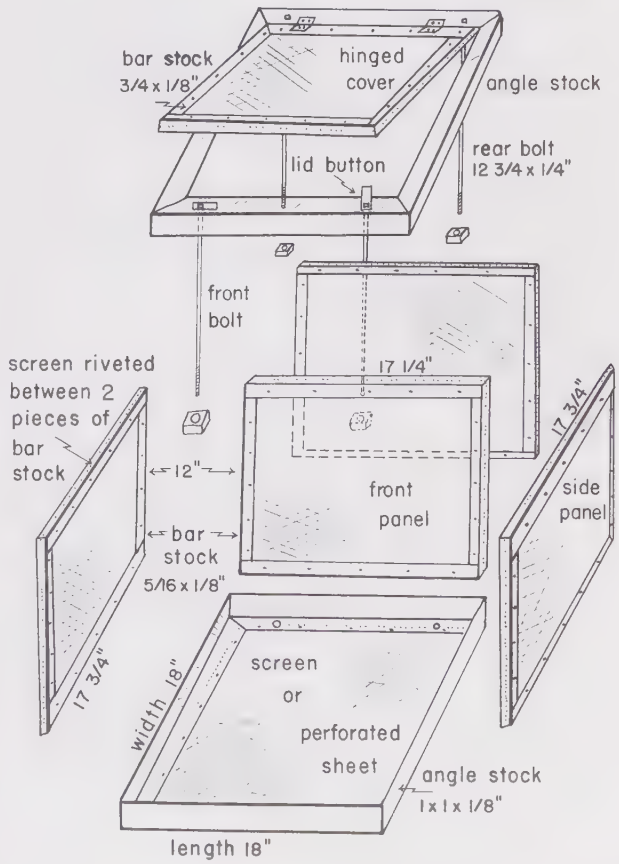
Various shapes and sizes of live-cars can be constructed with "do-it-yourself" aluminum stock.. The specifications given here apply to the live-cars shown in the photograph.

Two 6-foot pieces of angle stock were bent in squares 18 by 18 inches, one for the bottom and the other for the top of the

Right
Two live-cars made of "do-it-yourself" aluminum.



Below
Construction and assemblage details.



live-car. A piece of perforated sheet stock was cut and fitted into the bottom angle and anchored in place with aluminum rivets through strips of bar stock 5/16 inch wide. Side panels and lid were made of the same perforated sheet material and framed on both sides with riveted bar stock. (Aluminum screen could have been substituted for the perforated sheet stock, but it is less durable.)

The four side panels were made 12 inches high. Those for the front and rear sides were 17-1/4 inches long, and the others 17-3/4 inches long. (When the live-car is assembled, the shorter side panels force the longer ones against the top and bottom frames and help to support the structure.) Four steel bolts, treated with zinc chromate primer to prevent corrosive reaction with the aluminum, were fitted through holes in the angle stock to hold the top and bottom in place and to aid in supporting the side panels. Short pieces of bar stock were attached to the front bolts to serve as lid buttons.

All parts of the live-car, when disassembled, can be tied into a compact package.

The cost of materials per live-car amounted to approximately $16.

## MEANS OF TRACKING INDIVIDUAL FISH

Underwater sonic equipment is being developed by the U. S. Fish and Wildlife Service to obtain detailed knowledge of the movements of individual adult salmon in relation to dams on the Columbia River. Such information is needed for the effective operation of present fish-passage facilities and for the design and location of new facilities.

For tracking fish, a miniature underwater sonic transducer is to be fastened to the fish. This tracker is an aluminum capsule (2-3/8 inches long, less than an inch in diameter, weighing about 2 grams when immersed in water) that has a battery and electronic circuitry imbedded in styrene plastic foam at the center, a transistor attached in one end, and a resonating crystal cemented in the opposite end. The signals given by this transducer can be detected for 10 to 100 hours (depending on the size of battery used) at a distance of 2,000 feet in quiet fresh water. A fish carrying this capsule can be followed and its position pin-pointed for about 800 feet in still, clear water and for about 100 feet in rough, turbulent streams.

To minimize the effect on the natural movements of the fish, the sonic tag is attached to the fish under water and without handling or immobilizing the fish. A "hog-ring" of nickel chromium wire, its ends beveled to sharp edges, is centered in a hole in a brass rivet and then silver-soldered in place; the rivet, in turn, is soldered with aluminum to the outside of the transducer. The fish to be tagged is led into a small trap and permitted to become quiet. Then, with special pliers, the tag is gently placed on the back of the fish--2 inches behind the dorsal fin--and clinched shut in the flesh. Within 30 seconds after being tagged, the fish is released and the tracking of its movements with the receiving apparatus is started.

A receiver that automatically registers the movements of the transducer can be installed in a boat or placed on shore. An automatic-tracking device seeks out and "homes" on the sonic tag, and an echo-ranging system then supplies information about the position and movements of the tag. The bearing and distance of the fish can be read directly on a viewing screen; the angle of the beam of sound impulses can be seen on a tilt-angle meter. Given the distance and angle, the depth of the fish can be calculated. The signals of a loudspeaker help to interpret the returning echoes; the strength of the sound waves on a signal-level indicator shows roughly the distance of the fish.

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